(61)

ARCS I

Final Site Inspection Prioritization Report

Pine Swamp

Hamden, Connecticut

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY, Region I
Waste Management Division
Boston, MA

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INTRODUCTION

The CDM Federal Programs Corporation (CDM) Alternative Remedial Contracting Strategy (ARCS) team was requested by the U.S. Environmental Protection Agency (EPA) Region I Waste Management Division to perform a Site Inspection Prioritization (SIP) of the Pine Swamp property in Hamden, Connecticut. Tasks were conducted in accordance with the ARCS Contract No. 68-W9-0045, the SIP scope of work dated September 3, 1992, and technical specifications provided by EPA under Work Assignment No. 23-1JZZ, which was issued to CDM on September 22, 1992. A Preliminary Assessment (PA) was prepared by the NUS Corporation (NUS) in January, 1983. NUS performed a Site Inspection (SI) in June 1985.

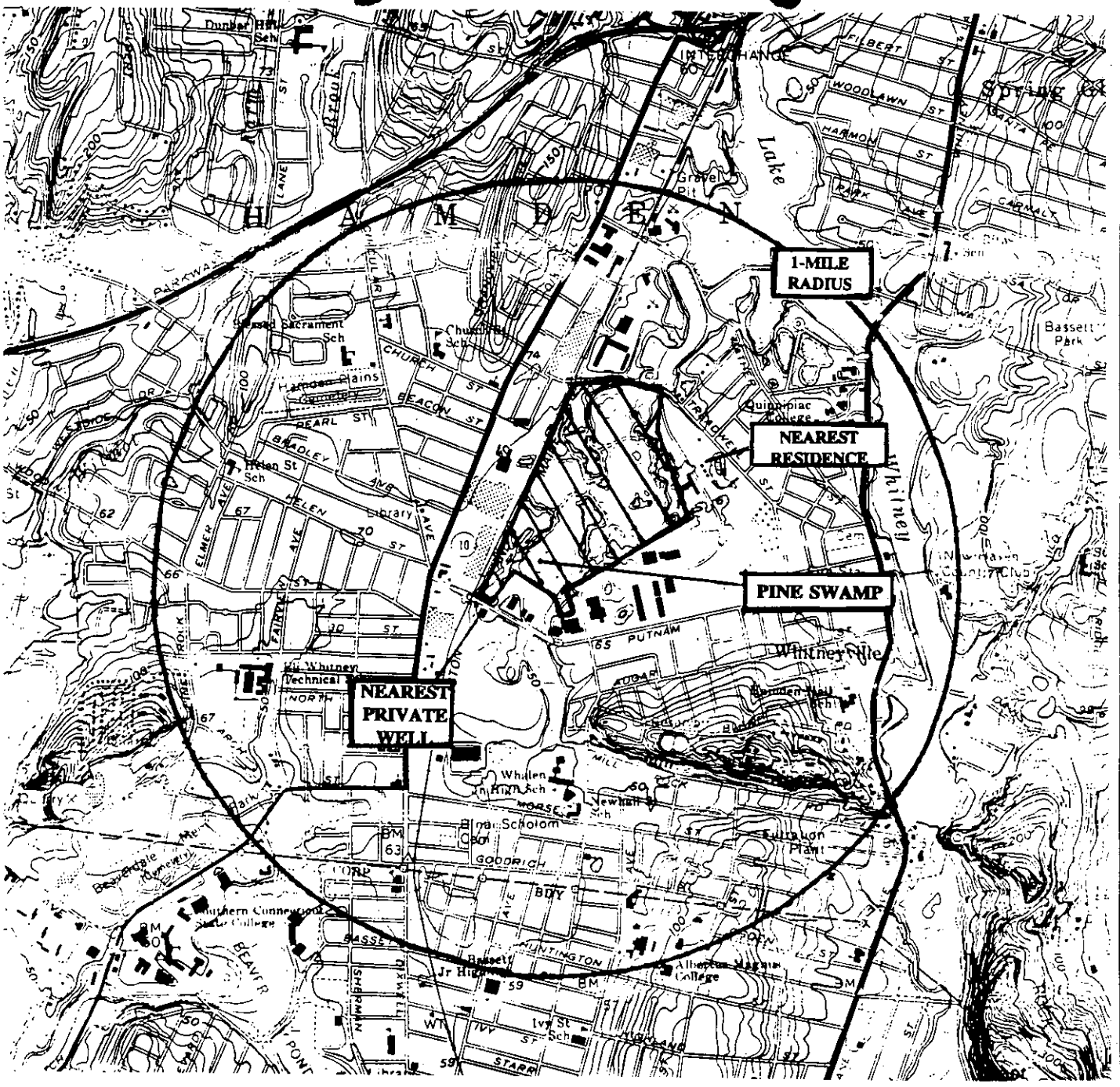
Background information used in the generation of this report was obtained through file searches conducted at the Connecticut Department of Environmental Protection (CTDEP), telephone interviews with town officials, conversations with persons knowledgeable of the Pine Swamp property and conversations with other federal, state, and local agencies. Additional information was collected during the CDM onsite reconnaissance on May 11, 1994, and environmental sampling on August 23, 1994.

This package follows the guidelines developed under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, commonly referred to as Superfund. However, these documents do not necessarily fulfill the requirements of other EPA regulations such as those under the Resource Conservation and Recovery Act (RCRA) or other federal, state, or local regulations. SIPs are intended to provide a preliminary screening of sites to facilitate EPA's assignment of site priorities. They are limited efforts and are not intended to supersede more detailed investigations.

SITE DESCRIPTION

Pine Swamp is located at 475 Putnam Avenue, in Hamden, New Haven County, Connecticut (Latitude 41° 20' 52" N, Longitude 72° 55' 30" W) (see Figure 1: Location Map) [2,19,41]. This 103.6-acre inactive property is owned by Olin Corporation (Olin) of Stamford, Connecticut (see Figure 2: Site Sketch) [3,10,23,24,47].

The area surrounding the Pine Swamp property is urban, including industrial, commercial, and residential sectors. A shopping center on Dixwell Avenue is located west of the property. Several businesses are located on Putnam Avenue and Leeder Hill Drive south and east respectively of the property, including Goodyear Retread, Atlantic Film Works, Bellmore Johnson



Source: Base map U.S. Geological Survey Topographical Map 7.5 x 15 minute series:
New Haven Quadrangle, Connecticut.

SCALE 1:24000

LOCATION MAP
PINE SWAMP
HAMDEN, CONNECTICUT

CDM FEDERAL PROGRAMS CORPORATION
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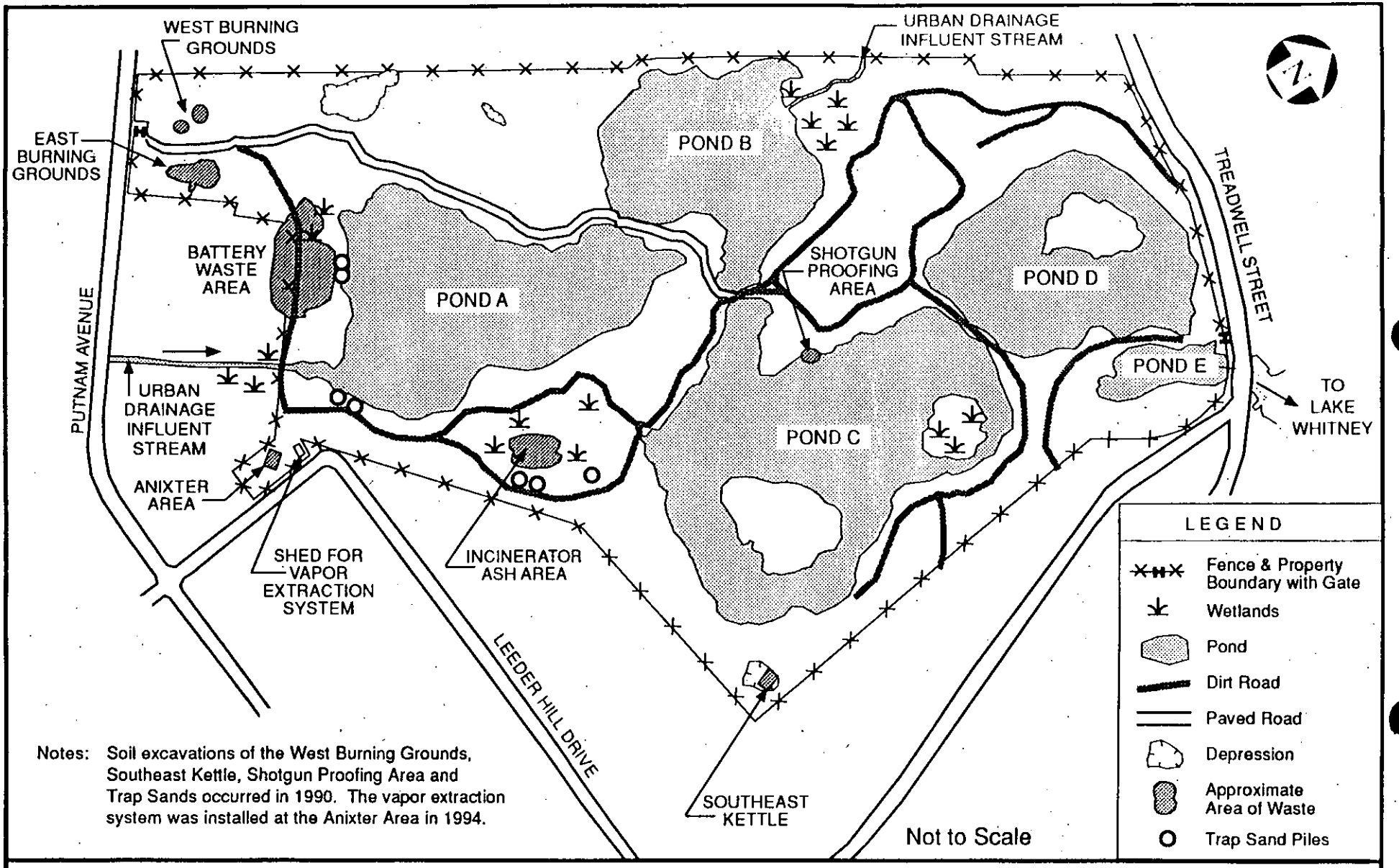
Figure 1



Notes: Soil excavations of the West Burning Grounds, Southeast Kettle, Shotgun Proofing Area and Trap Sands occurred in 1990. The vapor extraction system was installed at the Anixter Area in 1994.

SITE SKETCH
PINE SWAMP
HAMDEN, CONNECTICUT

CDM FEDERAL PROGRAMS CORPORATION
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Figure 2

Tool Company, H.A. Leed Company, Absolute Recyclers, Locknetics, United Technologies, Otis Elevator, Drill Masters Inc., Air Craft Radio, Precision Extruded, Miller Casket of New England, United Office Furniture, Southern New England Telephone, and the Whitney Center. Lake Whitney, several residences, and additional businesses, including Schindler, Genovese & Associates, A.R.C. Welding, Dexsil Chemicals, Hamden Health Center, Elm City Neon, and Lance Wire & Cable, are located north of the property [3].

The property consists of several paved and unpaved roads, wooded hills and five interconnected ponds with several wetland areas surrounding the ponds [3]. The ponds are hydrologically connected to Lake Whitney, a former public drinking water reservoir formed by a dam on the Mill River [3,12,47]. Lake Whitney is located 0.1 mile north of the Pine Swamp property. The drinking water intake is located approximately 3 miles downstream of the probable point of entry in the Pine Swamp pond system. The property generally slopes radially toward the ponds. The storm sewer system for the area surrounding the Pine Swamp property also drains into the ponds, including drainage from 658 total acres of commercial, light industrial, and residential land south of the property, 266 acres of commercial, industrial, and residential land northwest of the property, and 11 acres from the shopping center parking lot south of the property [30].

The only structure on the property is a 14-foot by 20-foot wooden shed in the southern corner of the property, which houses a soil vapor extraction system installed by Olin Corporation in 1994 for remediation purposes. The property is enclosed with a chain link fence with an access gate at Putnam Avenue [3].

OPERATIONAL AND REGULATORY HISTORY AND WASTE CHARACTERISTICS

The Winchester Repeating Arms Company (Winchester) of New Haven, Connecticut, purchased approximately 200 acres near Putnam Avenue around 1890 and constructed what is now Treadwell Street to establish the north boundary of the Pine Swamp property [3]. For approximately 60 years, Winchester, owned by Olin, stored gunpowder on the property. Shotgun, small caliber rifle, machine gun, and artillery shells, and mortar rounds, were tested at firing ranges on the Pine Swamp property. Approximately 35 bunkers were constructed throughout the property for storage of the gun powder. Thus, the local name for the Pine Swamp property, the "Powder Farm," was established [3,6,30].

Olin also used the Pine Swamp property for the disposal and incineration of materials generated at the New Haven Winchester plant, including "wood, demolition debris, miscellaneous metals and glass, trash, waste gunpowder and solvent chemicals, off-specification dry cell batteries, concrete test pads, trap sands from firing ranges, and incinerator ash" [6,30]. Batteries were produced at the New Haven facilities until 1957. Ammunition production ended in the late 1960s, which also ended the storage of gunpowder on the Pine Swamp property. Waste disposal and incineration operations began in the late 1950s and continued until the late 1960s. Waste was disposed of and burned primarily in the southwestern corner of the property [3,25].

In 1964, Olin sold approximately 100 acres of the original property in parcels, leaving a 102.8-acre property. In 1966, a private citizen complaint to the Hamden Health Department initiated the cessation of disposal and the commencement of restoration of the Pine Swamp property. Environmental Research and Technology, Inc. (ERT) performed an environmental investigation of the property for Olin in 1981. Phase II of the site investigation was performed by ERT in 1982. NUS Corporation prepared a Final Site Inspection in January 1985 for EPA. Olin Corporation entered into a Consent Order with the CTDEP in January 1986 to identify and remediate contaminated areas on the property. Early in 1987, Olin Corporation purchased 0.75 acre from the Anixter AED Company, forming the current 103.6-acre property) [3,6,7,13,30,31].

Malcolm Pirnie performed a Remedial Investigation Study (RIS) in December 1988 for Olin which identified the following six major areas for further study and remediation: the East Burning Grounds, the West Burning Grounds, the Battery Waste Area, the Anixter Area, the Southeast Kettle Area, and the Incinerator Ash Area. These areas, in addition to the Shotgun Proofing Area and the Trap Sands, also identified in the RIS, appear to comprise the main onsite disposal areas and are included in this report's source evaluation. Two offsite disposal areas, several onsite discrete demolition debris piles, one mixed waste debris pile, 75 Ramset test pads, and a 60-inch diameter backfilled brick "cistern" structure were also identified by the RIS; however, these areas were investigated, determined to be insignificant, and are not included as potential sources of contamination associated with the Pine Swamp property [30].

Olin implemented an Interim Corrective Measures (ICM) program, which included remediation of the West Burning Grounds, the Southeast Kettle, the Shotgun Proofing Area, and the Trap Sands. The ICM program was conducted by Malcolm Pirnie in 1990. Malcolm Pirnie prepared the Pine Swamp Interim Corrective Measures Report in June 1991. Also in 1991, Malcolm Pirnie began an annual onsite groundwater monitoring program for Olin [27].

CDM conducted onsite reconnaissance activities on May 11, 1994. The CDM field crew met with a representative from Olin and a representative from Olin's consulting firm, Malcolm Pirnie. Activities conducted during the reconnaissance included a site walkover, location of potential sampling locations, and documentation of the site history, current site conditions, and probable flow of groundwater and surface water [3].

CDM conducted sediment sampling at the property and groundwater sampling at a nearby drinking water well on August 23, 1994. The *Task Work Plan for Onsite Reconnaissance and Sampling at Pine Swamp* (August 1994) describes the sampling locations and rationale. Samples were collected in accordance with the Task Work Plan, with two minor exceptions, which are discussed in the *Trip Report for Onsite Reconnaissance and Sampling Activities* (September 1994). The data quality objectives established for the sampling event were met. Groundwater samples are described in the Groundwater Pathway section of this report. Sediment sample locations and descriptions are included in the Surface Water Pathway section of this report [3].

Table 1 provides a timeline of environmental audits, inspections, regulatory activities, and associated environmental issues relevant to Pine Swamp.

TABLE 1

Site Activity at Pine Swamp

Date	Activity
February 1966	Private citizen complaint to Hamden Health Department concerning dumping and burning of wastes in area of Putnam Avenue and Dixwell Avenue in Hamden, Connecticut.
March 1966	Hearing in office of Hamden Health Department directing Olin to cease transporting materials to site, to cease burning combustible material and to remove all non-combustible debris.
June 1966	Hamden Health Department follow-up inspections found chemical wastes removed and pits used for waste disposal and burning backfilled with clean fill.
1973	Demolition and removal of 35 concrete bunkers used for storage of gunpowder.
1979	Olin report to Congressional Subcommittee on Oversight and Investigation of Chemical Waste Disposal acknowledging disposal, incineration, and possible burial of industrial wastes (organics, metals, highly volatile acids).
January 1981	Environmental Research and Technology, Inc. (ERT) Phase I Report including hydrological investigation of test pits in disposal areas, installation of monitoring wells, sampling and analysis of groundwater, surface water, and sediment from ponds.
June 1982	ERT Phase II report including installation of additional borings and wells, and sampling of groundwater, surface water, and sediment from ponds. Results of sampling indicated onsite contamination in all three media.
January 1983	PA performed by NUS Corporation.
January 1984	CTDEP ordered the Anixter AED Company to remove VOC contaminated soil.
April/May 1984	Removal and backfill of soil by Anixter AED Company in rear of their property on Leeder Hill Drive and installation of monitoring wells.
May 1984	SI sampling, including soil, surface water, and groundwater, performed by NUS Corporation.
January 1985	Final SI report prepared by NUS Corporation.
January 1986	Consent Order signed by Olin and CTDEP Water Compliance Division for further investigation and remediation of site.
Early 1987	Olin purchased 0.75 acre of VOC contaminated land from Anixter AED Company.
December 1988	Remedial Investigation Study prepared by Malcolm Pirnie including Clean Sites Inc.'s letter of certification.

TABLE 1 (continued)

Date	Activity
1989	Olin begins quarterly monitoring of industrial process well at abutting property.
April 1990	210 cubic yards of contaminated soil excavated from the West Burning Grounds area and 180 cubic yards of exposed lead-contaminated ballistic trap sand excavated from sand trap piles throughout the site as part of Interim Corrective Measures program. Excavated material disposed of at an EPA permitted hazardous waste facility.
September 1990	200 cubic yards of debris, timbers, structural metal and rubble excavated from the Southeast Kettle area and transported to the Wallingford Landfill for disposal under Interim Corrective Measures program.
April 1991	Site wide groundwater monitoring conducted by Malcolm Pirnie.
June 1991	"Olin Pine Swamp Interim Corrective Measures Report" prepared by Malcolm Pirnie.
June 1991	Anixter Area PCB soil characterization performed by Malcolm Pirnie.
August 1992	Site-wide groundwater monitoring conducted by Malcolm Pirnie.
September 1992	Anixter Area "Site Investigation and Exposure Assessment" report prepared by ABB Environmental Services investigated extent of PCB contamination and associated risk and recommended proceeding with planned soil vapor extraction for VOCs.
April 1993	Onsite groundwater monitoring conducted by Malcolm Pirnie.
March 1994	Anixter site soil vacuum extraction system put on line by VAPEX Environmental Technologies, Inc. (VAPEX) for removal of VOCs.
May 1994	Site reconnaissance performed by CDM for SIP.
April 1994	Site-wide groundwater monitoring conducted by Malcolm Pirnie.
April 1994	Anixter Site Status Report No. 1 prepared by VAPEX summarizing deign, installation, and performance of the vapor extraction system for the period of January 18 through April 7, 1994.
June 1994	Anixter Site Status Report No. 2 prepared by VAPEX summarizing the performance of the vapor extraction system for the period of April 8 through June 7, 1994.
August 1994	Sediment and groundwater sampling conducted by CDM.
October 1994	Anixter Site Status Report No. 3 prepared by VAPEX summarizing the performance of the vapor extraction system for the period of June 8 through August 12, 1994.

VOC = Volatile Organic Compound
PA = Preliminary Assessment
SI = Site Inspection
PCB = Polychlorinated Biphenyl
SIP = Site Inspection Prioritization

[1,3,6,7,27,28,29,30,31,32,38

CERCLA Information System (CERCLIS) facilities, Newhall Street Field (EPA ID No. CTD982544355) and Himmel Brothers (EPA ID No. CTD001167543) are located within a 1-mile radius of Pine Swamp. No other CERCLIS facilities are located within a 1-mile radius of Pine Swamp; however, there are seven CERCLIS facilities in the town of Hamden [24]. There are ten RCRA facilities in the town of Hamden. Pine Swamp is not a RCRA facility [25].

Table 2 presents identified areas on the Pine Swamp property that are potential sources of contamination, the containment factors associated with each source, and the relative location of each source.

TABLE 2

Source Evaluation for Pine Swamp

Potential Source Area	Containment Factors	Spatial Location
East Burning Grounds	None	Southwest corner of property
Battery Waste Area	None	South of Pond A
Anixter Area	None	Southern corner of property
Incinerator Ash Area	None	Wetlands area south of Pond C
West Burning Grounds	None	Southeast corner of property
Southeast Kettle	None	East of Pond C
Shotgun Proofing Area	None	West of Pond C
Trap Sands	None	Along edges of Ponds A and C

[27,30]

The 1988 RIS provides the most comprehensive descriptions of the disposal areas:

> The East Burning Grounds, located within the southwest corner, is comprised of two discrete chemical disposal areas overlain by a blanket of miscellaneous fill. The areas are approximately 10,000 square feet, with waste/fill material two to 6 feet deep, and a total estimated volume of 1,200 cubic yards. Contaminants

are principally volatile organics to a maximum total concentration of 59.0 mg/kg, and undifferentiated debris including dry cell batteries [30].

The Battery Waste Area, included in the RIS by amendment, is also in the southwest corner. The fill area, characterized by dry cell battery artifacts, is approximately one acre in extent, two to 12 feet deep, and contains about 7,000 cubic yards. Contaminants are principally semi-volatile compounds and metals; specifically lead, manganese, and zinc at maximum concentrations of 62,000 mg/kg, 144,400 mg/kg, and 43,200 mg/kg, respectively. In addition to dry cell battery wastes, the area also contains ballistic catching sands and an unquantified volume of demolition debris [30].

The Anixter Area is located on a terrace at the southerly end of the site. It comprises a former chemical waste disposal area which has been partially remediated. The contaminated soil remaining is estimated to exceed 1,000 square feet, approximately 30 feet deep and consists of over 1,000 cubic yards. Contaminants are volatile organics to a maximum total of 2.65 mg/kg [30].

The Incinerator Ash Area is also located in the southerly end of the site and consists of an area of surface fill totalling 29,000 square feet, two feet deep, and approximately 2,140 cubic yards. Contaminants include volatile organics to a maximum total of 44.9 mg/kg, semi-volatiles, and metals. Lead concentration ranged to a maximum of 86,500 mg/kg. In addition to ash, waste materials include miscellaneous debris and ballistic catching sands [30].

The West Burning Grounds, adjoining the East Burning Grounds, contains two discrete disposal areas totalling 1,850 square feet, averaging 4.5 feet in depth, and containing about 300 cubic yards. Principal contaminants are volatile organics to a maximum total concentration of 24.0 mg/kg, semi-volatile compounds, and metals including lead at a maximum concentration of 77,200 mg/kg. The charred residue is overlain by metal powder canisters and racks from former munitions manufacturing [30].

The Southeast Kettle is a small, closed depression located in an isolated corner of the site. It is characterized by an area of demolition debris and an accumulation of empty drums that were removed in 1982. Approximately 525 square feet of the Kettle floor soils have low level volatile organic contamination of less than 0.20 mg/kg. The affected soils are approximately 5 feet deep with a total volume of about 100 cubic yards [30].

A shotgun proofing area was identified along the western bank of Pond C. Shotguns were reportedly proofed by firing into the area over Pond C. The shotgun firing area is characterized by a large accumulation of spent plastic shell casings both on the bank and in the surrounding shallow water [30].

Eight discrete piles of sand and spent small caliber bullets identified as trap sands from the firing ranges were located. These piles have a distinct greenish grey color that is enhanced by the metal bullet remains. These piles are approximately 3 feet x 3 feet in area with one exception. The sand pile located directly east of the Incinerator Ash area ... is much larger in extent [30].

Table 3 summarizes the types of potentially hazardous substances that have been disposed of, used, or stored on the property.

TABLE 3

Hazardous Waste Quantity for Pine Swamp

Substance	Quantity or Volume/Area	Source Area
Dry cell batteries, solvents	1,200 yd^3 / 10,000 ft^2	East Burning Grounds
Dry cell batteries, debris	7,000 yd^3 / 43,560 ft^2	Battery Waste Area
Solvents, PCBs	1,000 yd^3 / 1,000 ft^2	Anixter Area
Incinerator ash, debris	2,140 yd^3 / 29,000 ft^2	Incinerator Ash Area
Solvents, PCBs, debris	300 yd^3 / 1,850 ft^2	West Burning Grounds
Overpack drums, incinerator ash, debris	100 yd^3 / 525 ft^2	Southeast Kettle
Debris (empty shotgun casings)	2 yd^3 / 1,200 ft^2	Shotgun Proofing Area
Trap sands (spent bullets, fragments, abraded lead)	50 yd^3 / 3,000 ft^2	Trap Sands

Note: Disposal and incineration operations began in the late 1950s and ceased in 1966.

[27,30]

As discussed above, Olin implemented an Interim Corrective Measures (ICM) program, which included remediation of the West Burning Grounds, the Southeast Kettle, the Shotgun Proofing Area, and discrete trap sand piles in 1990. Soil from the West Burning Grounds was removed to remedial criteria agreed upon by CTDEP. The Shotgun Proofing Area, which represents a disposal area of non-hazardous debris, was also remediated, leaving some empty shell casings at the location. Discrete demolition debris piles and 75 Ramset test pads were also excavated. Three trap sand piles were removed to the remedial criteria. Two trap sand piles were removed to meet the Extraction Procedure (EP) toxicity criteria of less than 5.0 milligrams per liter (mg/l) lead at the limit of excavation and were covered with clean fill and seeded to satisfy the CTDEP criteria that residual soils greater than 500 milligrams per kilogram (mg/kg) total lead be covered with at least 1 foot of clean fill. The two trap sand piles located in the Battery Waste Area were not remediated and are included in the Battery Waste Area hazardous waste quantity [27]. Because the ICM was performed in 1990, following the 1985 SI, the remediated source areas are included in the source evaluation for the purposes of the SIP [27,43].

During the ICM program, polychlorinated biphenyls (PCBs) were detected in soils from the West Burning Grounds and the Anixter Area. The ICM included a soil vapor extraction pilot test for the Anixter Area [27].

The ICM remediation was performed under agreement with the CTDEP and in accordance with local permits by the Hamden Planning and Zoning Commission and Hamden Conservation Commission. In addition to the state and local agency oversite, the South Central Connecticut Regional Water Authority (SCCRWA) was also informed and involved in the program [27].

WASTE/SOURCE SAMPLING

Contaminated soil on the Pine Swamp property has been characterized by several sampling events that occurred between 1982 and 1994. The 1982 ERT Phase II report prepared for Olin included soil sampling which were analyzed for cadmium, chromium, lead, manganese, mercury, and zinc. Eighteen soil samples were taken from nine borings between December 8, 1981, and December 18, 1981. Maximum concentrations of the analytes in the EP toxicity leachate derived from the soil samples were the following: 1.2 milligrams per liter (mg/l) cadmium, 160 mg/l lead, 170 mg/l manganese, 2.7 micrograms per liter (μg/l) mercury, and 1,000 mg/l zinc. Chromium was not detected in any of the soil samples. Four of the samples from the Battery Waste Area were characterized as hazardous waste due to elevated lead and/or cadmium concentrations according to EPA criteria [7].

The 1985 NUS Corporation Site Inspection prepared for EPA included the collection of two soil samples, plus a duplicate sample and a soil blank on May 15 and 16, 1984. The soil samples were analyzed using EPA Contract Laboratory Program (CLP) protocols for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and inorganic analytes. Soil sample S-1/S-1 Duplicate, collected near the battery waste area at a depth of 6 inches, contained no VOCs; several SVOCs, including 2,000 J parts per billion (ppb) di-n-butyl phthalate, 450 J ppb benzo(a)anthracene, 460 J ppb chrysene, 840 J ppb pyrene, 520 J ppb N-nitrosodiphenylamine, and 620 J ppb fluorene; and several inorganic analytes at three times above the background concentration, including 174 parts per million (ppm) copper, 14,700 J ppm manganese, 4,740 ppm zinc, 2.3 J ppm mercury, 2.4 J ppm cadmium, and 204 J ppm lead. Soil sample S-3, collected near the incinerator ash area at a depth of 12 inches, contained one VOC, trichloroethylene, at 9.0 J ppb; several SVOCs, including 1,400 ppb fluoranthene, 910 ppb bis(2-ethylhexyl)phthalate, 710 ppb benzo(a)anthracene, 820 ppb chrysene, 1,200 ppb phenanthrene, and 1,400 ppb pyrene; and several inorganic analytes at three times the background concentration, including 254 ppm barium, 2,130 ppm copper, 75 ppm nickel, 1,100 ppm zinc, 4.0 ppm silver, and 4.2 ppm tin [31].

The 1988 RIS performed by Malcolm Pirnie for Olin provides the most comprehensive source sampling for the Pine Swamp property. The sampling was performed from 1986 through 1988. Samples for the RIS were analyzed using EPA CLP protocols. Table 4 describes the samples collected for the RIS, and Table 5 summarizes the analytical results of representative samples [30].

TABLE 4

Summary of Source Samples Collected by Malcolm Pirnie from 1986 - 1988

Sample Location No.	Date Sample Collected	Analysis Performed	Remarks/Depth	Source Area
EB1-3	7/28/87	HSL	Grab / 4.5'-6.5'	East Burning Grounds
EB2-4	7/28/87	HSL	Grab / 6'-8'	East Burning Grounds
EB3-2	7/28/87	HSL	Grab / 6'-8'	East Burning Grounds
BW-1	1/26/88	HSL	Grab / 2'-5'	Battery Waste Area
BW-2	1/26/88	HSL	Grab / 2'-4.5'	Battery Waste Area
BW-3	1/26/88	HSL	Grab / 2'-6.4'	Battery Waste Area
AB5-3	9/30/86-10/1/86	VOC	Grab / 3'	Anixter Area
AB5-5	9/30/86-10/1/86	VOC	Grab / 5'	Anixter Area
IA-1	2/9/88-2/10/88	HSL	Grab / 0'-5'	Incinerator Ash Area
IA-2	2/9/88-2/10/88	HSL	Grab / 0'-5'	Incinerator Ash Area
IA-4	2/9/88-2/10/88	HSL	Grab / 0'-4'	Incinerator Ash Area
IA-6	2/9/88-2/10/88	HSL	Grab / 6"-12"	Incinerator Ash Area
WBG1-1	1/26/88	HSL	Grab /2.1'-7'	West Burning Grounds
WBG2-1	1/26/88	HSL	Grab / 0.2'-3.5'	West Burning Grounds
WBG2-3	1/26/88	HSL	Grab / 4.0'-5.5'	West Burning Grounds
WBG2-4	1/26/88	HSL	Grab / 4.0'-5.5'	West Burning Grounds - Background Sample
KB4-3	9/30/86-10/1/86	VOC	Grab / 4'-6'	Southeast Kettle

HSL = Full Hazardous Substance List including VOCs, Bases/Neutrals/Acids, Pesticides/PCBs, metals and cyanide using USEPA Contract Laboratory Program (CLP) protocols.
VOC = Volatile organic analysis using USEPA Contract Laboratory Program (CLP) protocols.
NA = Not available.

[30]

Soil sample WBG2-4, collected in the West Burning Grounds outside of the contaminated area, is used as the background sample. For each sample location, a compound or analyte is listed if it is detected at a concentration three times or greater than the reference sample concentration. Compounds or analytes that occur at a concentration three times or greater than the reference concentration are designated by their approximate relative concentration above the reference value. If the compound or analyte was not detected in the reference sample, the sample quantitation limit (SQL) or sample detection limit (SDL) is used as a reference value. Accordingly, compounds/analytes are listed by their approximate concentration above the SQL/SDL only if they occur at a concentration equal to or greater than the reference sample's SQL/SDL.

TABLE 5

Summary of Analytical Results
Source Sample Analysis for Pine Swamp
Collected by Malcolm Pirnie from 1986-1988

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
EB1-3	Tetrachloroethene	300 J µg/kg	6 U µg/kg	50 x SQL
	Toluene	2,100 µg/kg	6 U µg/kg	400 x SQL
	Chlorobenzene	6,200 µg/kg	6 U µg/kg	1,000 x SQL
	Ethylbenzene	280 J µg/kg	6 U µg/kg	50 x SQL
	Total xylenes	2,400 µg/kg	6 U µg/kg	400 x SQL
	Aroclor-1260	36,000 B µg/kg	8,200 B µg/kg	4.4 x SQL
	Arsenic	1.6 mg/kg	0.2 mg/kg	8 x REF
	Chromium	34 mg/kg	5.2 mg/kg	6.5 x REF
	Copper	287 mg/kg	19.0 mg/kg	15.1 x REF
	Lead	277 mg/kg	5.8 mg/kg	48 x REF
	Mercury	1.8 mg/kg	0.45 mg/kg	4.0 x REF
	Nickel	18 mg/kg	3.4 B mg/kg	5.3 x REF
	Selenium	0.78 mg/kg	0.2 U mg/kg	4 x SDL
	Zinc	444 mg/kg	103 mg/kg	4.31 x REF

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
EB2-4	Trichloroethene	30 µg/kg	6 U µg/kg	5 x SQL
	Arsenic	1.1 mg/kg	0.2 mg/kg	5.5 x REF
	Beryllium	0.34 mg/kg	0.1 U mg/kg	3.4 x SDL
	Chromium	22 mg/kg	5.2 mg/kg	4.2 x REF
	Cobalt	6.1 mg/kg	2.0 mg/kg	3.1 x REF
	Copper	106 mg/kg	19.0 mg/kg	5.58 x REF
	Lead	75 mg/kg	5.8 mg/kg	13 x REF
EB3-2	Trichloroethene	51 µg/kg	6 U µg/kg	8.5 x SQL
	Arsenic	0.63 mg/kg	0.2 mg/kg	3 x REF
	Lead	35 mg/kg	5.8 mg/kg	6.0 x REF
	Aroclor-1248	13,000 B µg/kg	8,200 U µg/kg	1.6 x SQL
BW-1	4-Methylphenol	440 J µg/kg	380 U µg/kg	1.2 x SQL
	Naphthalene	620 J µg/kg	380 U µg/kg	1.6 x SQL
	2-Methylnaphthalene	440 J µg/kg	380 U µg/kg	1.2 x SQL
	Acenaphthylene	2,300 µg/kg	380 U µg/kg	6.1 x SQL
	Fluorene	1,400 µg/kg	380 U µg/kg	3.7 x SQL
	Phenanthrene	6,200 µg/kg	380 U µg/kg	16 x SQL
	Anthracene	1,800 µg/kg	380 U µg/kg	4.7 x SQL
	Pyrene	8,800 µg/kg	380 U µg/kg	23 x SQL
	Benzo(a)anthracene	7,300 µg/kg	380 U µg/kg	19 x SQL
	Chrysene	9,200 µg/kg	380 U µg/kg	24 x SQL
	Benzo(k)fluoranthene	1,000 µg/kg	380 U µg/kg	2.6 x SQL
	Indeno(1,2,3-cd)pyrene	700 µg/kg	380 U µg/kg	1.8 x SQL

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
BW-1 (continued)	Benzo(g,h,i)perylene	740 µg/kg	380 U µg/kg	1.9 x SQL
	Arsenic	177 mg/kg	0.2 B mg/kg	900 x REF
	Barium	2,250 mg/kg	98.0 mg/kg	23.0 x REF
	Beryllium	0.4 mg/kg	0.1 U mg/kg	4 x SDL
	Cadmium	13.0 mg/kg	0.3 U mg/kg	40 x SDL
	Chromium	262 mg/kg	5.2 mg/kg	50 x REF
	Cobalt	25.0 mg/kg	2.0 mg/kg	13 x REF
	Copper	2,850 mg/kg	19.0 mg/kg	150 x REF
	Iron	78,800 mg/kg	4,370 mg/kg	18.0 x REF
	Lead	48,400 mg/kg	5.8 mg/kg	8,300 x REF
	Manganese	81,500 mg/kg	174 mg/kg	468 x REF
	Mercury	8.8 mg/kg	0.45 mg/kg	20 x REF
	Nickel	147 mg/kg	3.4 mg/kg	43.2 x REF
	Vanadium	36.0 mg/kg	9.8 mg/kg	3.7 x REF
	Zinc	17,700 mg/kg	103 mg/kg	172 x REF
	Cyanide	6.4 mg/kg	0.5 U mg/kg	13 x SDL
BW-2	Acetone	110 µg/kg	31 B µg/kg	3.5 x REF
	2-Butanone	16 J µg/kg	12 U µg/kg	1.3 x SQL
	Toluene	22 µg/kg	6 U µg/kg	4 x SQL
	Total xylenes	44 µg/kg	6 U µg/kg	7 x SQL
	Phenol	1,400 µg/kg	380 U µg/kg	3.7 x SQL
	4-Methylphenol	3,800 µg/kg	380 U µg/kg	10 x SQL
	Benzoic acid (2)	2,200 J µg/kg	1,900 U µg/kg	1.2 x SQL

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
BW-2 (continued)	Naphthalene	1,700 µg/kg	380 U µg/kg	4.5 x SQL
	2-Methylnaphthalene	930 µg/kg	380 U µg/kg	2.4 x SQL
	Acenaphthylene	6,500 µg/kg	380 U µg/kg	17 x SQL
	Acenaphthene	770 J µg/kg	380 U µg/kg	2.0 x SQL
	Dibenzofuran	1,300 µg/kg	380 U µg/kg	3.4 x SQL
	Fluorene	3,300 µg/kg	380 U µg/kg	8.7 x SQL
	Phenanthrene	10,000 µg/kg	380 U µg/kg	26 x SQL
	Anthracene	5,300 µg/kg	380 U µg/kg	14 x SQL
	Benzo(a)anthracene	17,000 µg/kg	380 U µg/kg	45 x SQL
	Chrysene	21,000 µg/kg	380 U µg/kg	55 x SQL
	Aluminum	10,700 mg/kg	2,750 mg/kg	3.89 x REF
	Arsenic	34.0 mg/kg	0.2 mg/kg	170 x REF
	Barium	2,600 mg/kg	98.0 mg/kg	27 x REF
	Beryllium	0.5 mg/kg	0.1 U mg/kg	5 x SDL
	Cadmium	25.0 mg/kg	0.3 U mg/kg	80 x SDL
	Calcium	2,490 mg/kg	682 mg/kg	3.65 x REF
	Chromium	161 mg/kg	5.2 mg/kg	31 x REF
	Cobalt	13.0 mg/kg	2.0 mg/kg	6.5 x REF
	Copper	626 mg/kg	19.0 mg/kg	32.9 x REF
	Iron	15,900 mg/kg	4,370 mg/kg	3.64 x REF
	Lead	2,180 mg/kg	5.8 mg/kg	380 x REF
	Manganese	31,000 mg/kg	174 mg/kg	180 x REF
	Mercury	11.0 mg/kg	0.45 mg/kg	24 x REF

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
BW-2 (continued)	Nickel	42.0 mg/kg	3.4 mg/kg	12 x REF
	Vanadium	38.0 mg/kg	9.8 mg/kg	3.9 x REF
	Zinc	18,300 mg/kg	1.3 mg/kg	14,000 x REF
	Cyanide	4.5 mg/kg	0.5 U mg/kg	9 x SDL
BW-3	2-Butanone	20 µg/kg	12 U µg/kg	1.7 x SQL
	Total xylenes	6 J µg/kg	6 U µg/kg	1 x SQL
	Phenanthrene	3,000 µg/kg	380 U µg/kg	7.9 x SQL
	Anthracene	710 µg/kg	380 U µg/kg	1.9 x SQL
	di-n-Butyl phthalate	1,200 µg/kg	140 J µg/kg	8.6 x REF
	Fluoranthene	3,900 µg/kg	380 U µg/kg	10 x SQL
	Pyrene	2,200 µg/kg	380 U µg/kg	5.8 x SQL
	Benzo(a)anthracene	1,700 µg/kg	380 U µg/kg	4.5 x SQL
	bis(2-Ethylhexyl) phthalate	1,800 µg/kg	69 J µg/kg	26 x REF
	Chrysene	2,200 µg/kg	380 U µg/kg	5.8 x SQL
	Benzo(b)fluoranthene	1,300 µg/kg	380 U µg/kg	3.4 x SQL
	Benzo(k)fluoranthene	1,100 µg/kg	380 U µg/kg	2.9 x SQL
	Benzo(a)pyrene	1,200 µg/kg	380 U µg/kg	3.2 x SQL
	Indeno(1,2,3-cd)pyrene	750 µg/kg	380 U µg/kg	2.0 x SQL
	Benzo(g,h,i)perylene	800 µg/kg	380 U µg/kg	2.1 x SQL
	Arsenic	102 mg/kg	0.2 mg/kg	500 x REF
	Beryllium	0.5 mg/kg	0.1 U mg/kg	5 x SDL
	Cadmium	24.0 mg/kg	0.3 U mg/kg	80 x SDL

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
BW-3 (continued)	Chromium	65.0 mg/kg	5.2 mg/kg	13 x REF
	Cobalt	23.0 mg/kg	2.0 mg/kg	12 x REF
	Copper	1,590 mg/kg	19.0 mg/kg	83.7 x REF
	Lead	2,730 mg/kg	5.8 mg/kg	470 x REF
	Manganese	144,000 mg/kg	174 mg/kg	828 x REF
	Mercury	19.0 mg/kg	0.45 mg/kg	42 x REF
	Nickel	111 mg/kg	3.4 mg/kg	33 x REF
	Silver	6.6 mg/kg	0.6 U mg/kg	11 x SDL
	Zinc	42,400 mg/kg	103 mg/kg	412 x REF
AB5-3	Chloroform	6.4 µg/kg	6 U µg/kg	1.1 x SQL
	Carbon tetrachloride	6.6 µg/kg	6 U µg/kg	1.1 x SQL
	Trichloroethene	17 µg/kg	6 U µg/kg	2.8 x SQL
	Tetrachloroethene	2,600 µg/kg	6 U µg/kg	430 x SQL
AB5-5	Trichloroethene	36 µg/kg	6 U µg/kg	6 x SQL
	Tetrachloroethene	2,600 µg/kg	6 U µg/kg	400 x SQL
IA-1	Chloroform	13 µg/kg	6 U µg/kg	2 x SQL
	2-Butanone	14 J µg/kg	12 U µg/kg	1.2 x SQL
	1,1,1-Trichloroethane	11 µg/kg	6 U µg/kg	2 x SQL
	1,2-Dichloropropane	24 µg/kg	6 U µg/kg	4 x SQL
	Trichloroethene	170 µg/kg	6 U µg/kg	30 x SQL
	Benzene	18 µg/kg	6 U µg/kg	3 x SQL
	Tetrachloroethene	1,100 µg/kg	6 U µg/kg	180 x SQL
	1,1,2,2-Tetrachloroethane	12 µg/kg	6 U µg/kg	2 x SQL

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
IA-1 (continued)	Toluene	590 µg/kg	6 U µg/kg	100 x SQL
	Ethylbenzene	13 µg/kg	6 U µg/kg	2 x SQL
	Total xylenes	75 µg/kg	6 U µg/kg	10 x SQL
	1,2-Dichlorobenzene	5,900 µg/kg	380 U µg/kg	16 x SQL
	di-n-Butyl phthalate	930 µg/kg	140 J µg/kg	6.6 x REF
	Chrysene	1,000 µg/kg	380 U µg/kg	2.6 x SQL
	Arsenic	19.0 mg/kg	0.2 mg/kg	95 x REF
	Barium	3,780 mg/kg	98.0 mg/kg	38.6 x REF
	Beryllium	0.4 mg/kg	0.1 U mg/kg	4 x SDL
	Cadmium	16.0 mg/kg	0.3 U mg/kg	53 x SDL
	Calcium	22,600 mg/kg	682 mg/kg	33.1 x REF
	Chromium	111.0 mg/kg	5.2 mg/kg	21 x REF
	Cobalt	27.0 mg/kg	2.0 mg/kg	14 x REF
	Copper	6,380 mg/kg	19.0 mg/kg	336 x REF
	Iron	60,600 mg/kg	4,370 mg/kg	13.9 x REF
	Lead	86,500 mg/kg	5.8 mg/kg	15,000 x REF
	Magnesium	5,170 mg/kg	1,160 mg/kg	4.46 x REF
	Manganese	3,020 mg/kg	174 mg/kg	17.4 x REF
	Mercury	1.5 mg/kg	0.45 mg/kg	3.3 x REF
	Nickel	149 mg/kg	3.4 mg/kg	44 x REF
	Silver	4.2 mg/kg	0.6 U mg/kg	7 x SDL
	Sodium	984 mg/kg	7.3 U mg/kg	130 x SDL
	Vanadium	38.0 mg/kg	9.8 mg/kg	3.9 x REF

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
IA-1 (continued)	Zinc	8,860 mg/kg	103 mg/kg	86.0 x REF
	Aroclor-1260	38,000 B µg/kg	8,200 U µg/kg	4.6 x SQL
IA-2	Methylene chloride	820 JB µg/kg	15 B µg/kg	55 x REF
	Acetone	830 JB µg/kg	31 B µg/kg	27 x REF
	trans-1,2-Dichloroethene	310 J µg/kg	6 U µg/kg	50 x SQL
	1,2-Dichloroethane	750 J µg/kg	6 U µg/kg	100 x SQL
	2-Butanone	670 J µg/kg	12 U µg/kg	56 x SQL
	Trichloroethene	2,100 µg/kg	6 U µg/kg	400 x SQL
	Benzene	1,600 µg/kg	6 U µg/kg	300 x SQL
	Tetrachloroethene	6,800 µg/kg	6 U µg/kg	1,000 x SQL
	Toluene	7,300 µg/kg	6 U µg/kg	1,000 x SQL
	Ethylbenzene	930 µg/kg	6 U µg/kg	200 x SQL
	Total xylenes	7,900 µg/kg	6 U µg/kg	1,000 x SQL
	bis(2-Ethylhexyl) phthalate	1,400 µg/kg	69 J µg/kg	20 x REF
	Aluminum	8,340 mg/kg	2,750 mg/kg	3.03 x REF
	Arsenic	17.0 mg/kg	0.2 mg/kg	85 x REF
	Barium	5,770 mg/kg	98.0 mg/kg	58.9 x REF
	Beryllium	0.6 mg/kg	0.1 U mg/kg	6 x SDL
	Cadmium	23.0 mg/kg	0.3 U mg/kg	77 x SDL
	Calcium	18,700 mg/kg	682 mg/kg	27.4 x REF
	Chromium	102 mg/kg	5.2 mg/kg	20 x REF
	Cobalt	220 mg/kg	2.0 mg/kg	110 x REF

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
IA-2 (continued)	Copper	2,920 mg/kg	19.0 mg/kg	154 x REF
	Iron	79,300 mg/kg	4,370 mg/kg	18.1 x REF
	Lead	2,640 mg/kg	5.8 mg/kg	460 x REF
	Magnesium	4,770 mg/kg	1,160 mg/kg	4.11 x REF
	Manganese	1,700 mg/kg	174 mg/kg	9.8 x REF
	Mercury	3.2 mg/kg	0.45 mg/kg	7.1 x REF
	Nickel	178 mg/kg	3.4 mg/kg	52 x REF
	Selenium	0.9 mg/kg	0.2 U mg/kg	4.5 x SDL
	Sodium	468 mg/kg	7.3 U mg/kg	64 x SDL
	Vanadium	81.0 mg/kg	9.8 mg/kg	8.3 x REF
	Zinc	11,800 mg/kg	103 mg/kg	115 x REF
	Cyanide	43.0 mg/kg	0.5 U mg/kg	86 x SDL
	Aroclor-1248	480,000 B µg/kg	25,000 µg/kg	19 x REF
	Aroclor-1260	96,000 B µg/kg	8,200 U µg/kg	12 x SQL
IA-4	Methylene chloride	840 JB µg/kg	15 B µg/kg	56 x REF
	Acetone	740 JB µg/kg	31 B µg/kg	24 x REF
	trans-1,2-Dichloroethene	660 J µg/kg	6 U µg/kg	100 x SQL
	2-Butanone	510 J µg/kg	12 U µg/kg	43 x SQL
	1,2-Dichloropropane	680 J µg/kg	6 U µg/kg	100 x SQL
	Trichloroethene	27,000 µg/kg	6 U µg/kg	5,000 x SQL
	Toluene	3,200 µg/kg	6 U µg/kg	500 x SQL
	Ethylbenzene	280 J µg/kg	6 U µg/kg	50 x SQL
	Total xylenes	2,400 µg/kg	6 U µg/kg	400 x SQL

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
IA-4 (continued)	2,4-Dichlorophenol	1,100 µg/kg	380 U µg/kg	2.9 x SQL
	2,4-Dinitrotoluene	710 µg/kg	480 U µg/kg	1.5 x SQL
	di-n-Butyl phthalate	6,700 µg/kg	140 J µg/kg	48 x REF
	bis(2-Ethylhexyl) phthalate	8,500 µg/kg	69 J µg/kg	120 x REF
	di-n-Octyl phthalate	440 J µg/kg	380 U µg/kg	1.2 x SQL
	Arsenic	9.9 mg/kg	0.2 mg/kg	50 x REF
	Barium	3,800 mg/kg	98.0 mg/kg	39 x REF
	Beryllium	0.5 mg/kg	0.1 U mg/kg	5 x SDL
	Cadmium	20.0 mg/kg	0.3 U mg/kg	67 x SDL
	Calcium	16,800 mg/kg	682 mg/kg	24.6 x REF
	Chromium	219 mg/kg	5.2 mg/kg	42 x REF
	Cobalt	25.0 mg/kg	2.0 mg/kg	13 x REF
	Copper	4,160 mg/kg	19.0 mg/kg	219 x REF
	Iron	87,400 mg/kg	4,370 mg/kg	20.0 x REF
	Lead	30,100 mg/kg	5.8 mg/kg	5,200 x REF
	Magnesium	6,550 mg/kg	1,160 mg/kg	5.65 x REF
	Manganese	2,020 mg/kg	174 mg/kg	11.6 x REF
	Mercury	1,260 mg/kg	0.45 mg/kg	2,800 x REF
	Nickel	140 mg/kg	3.4 mg/kg	41 x REF
	Potassium	399 mg/kg	198 U mg/kg	2.01 x SDL
	Selenium	0.9 mg/kg	0.2 U mg/kg	4.5 x SDL
	Silver	36.0 mg/kg	0.6 U mg/kg	60 x SDL

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
IA-4 (continued)	Sodium	202 mg/kg	7.3 U mg/kg	28 x SDL
	Thallium	0.6 mg/kg	0.4 U mg/kg	1 x SDL
	Vanadium	43.0 mg/kg	9.8 mg/kg	4.4 x REF
	Zinc	8140 mg/kg	103 mg/kg	79.0 x REF
IA-6	Vinyl chloride	1,000 J µg/kg	12 U µg/kg	83 x SQL
	Methylene chloride	1,300 JB µg/kg	15 B µg/kg	87 x REF
	Acetone	1,400 JB µg/kg	31 B µg/kg	45 x REF
	trans-1,2-Dichloroethene	6,900 µg/kg	6 U µg/kg	1,000 x SQL
	2-Butanone	550 J µg/kg	12 U µg/kg	46 x SQL
	Trichloroethene	37,000 µg/kg	6 U µg/kg	6,000 x SQL
	Toluene	480 J µg/kg	6 U µg/kg	80 x SQL
	Phenanthrene	1,200 B µg/kg	380 U µg/kg	3.2 x SQL
	Fluoranthene	2,300 B µg/kg	380 J µg/kg	6.1 x REF
	Pyrene	1,900 B µg/kg	380 J µg/kg	5.0 x REF
	Benzo(a)anthracene	1,200 µg/kg	380 J µg/kg	3.2 x REF
	bis(2-Ethylhexyl) phthalate	4,000 µg/kg	69 J µg/kg	58 x REF
	Chrysene	1,400 µg/kg	380 U µg/kg	3.7 x SQL
	Benzo(b)fluoranthene	1,000 µg/kg	380 U µg/kg	2.6 x SQL
	Antimony	242 mg/kg	4.4 U mg/kg	55 x SDL
	Arsenic	13.0 mg/kg	0.2 mg/kg	65 x REF
	Barium	2,060 mg/kg	98.0 mg/kg	21.0 x REF
	Beryllium	0.5 B mg/kg	0.1 U mg/kg	5 x SDL

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
IA-6 (continued)	Cadmium	5.1 mg/kg	0.3 U mg/kg	17 x SDL
	Calcium	6,160 mg/kg	682 mg/kg	9.03 x REF
	Chromium	109 mg/kg	5.2 mg/kg	21 x REF
	Cobalt	15.0 mg/kg	2.0 mg/kg	7.5 x REF
	Copper	1,790 mg/kg	19.0 mg/kg	94.2 x REF
	Iron	23,400 mg/kg	4,370 mg/kg	5.35 x REF
	Lead	3,830 mg/kg	5.8 mg/kg	660 x REF
	Manganese	4,040 mg/kg	174 mg/kg	23.2 x REF
	Mercury	3.9 mg/kg	0.45 mg/kg	8.7 x REF
	Nickel	85.0 mg/kg	3.4 mg/kg	25 x REF
	Selenium	0.4 mg/kg	0.2 U mg/kg	2 x SDL
	Silver	8.2 mg/kg	0.6 U mg/kg	14 x SDL
	Sodium	49.0 mg/kg	7.3 U mg/kg	6.7 x SDL
	Vanadium	43.0 mg/kg	9.8 mg/kg	4.4 x REF
	Zinc	4,250 mg/kg	103 mg/kg	41.3 x REF
WBG1-1	1,1-Dichloroethane	13 J µg/kg	6 U µg/kg	2 x SQL
	Chloroform	150 µg/kg	6 U µg/kg	30 x SQL
	1,2-Dichloroethane	75 µg/kg	6 U µg/kg	10 x SQL
	1,1,1-Trichloroethane	91 µg/kg	6 U µg/kg	20 x SQL
	Trichloroethene	110 µg/kg	6 U µg/kg	20 x SQL
	Benzene	17 µg/kg	6 U µg/kg	3 x SQL
	Tetrachloroethene	170 µg/kg	6 U µg/kg	30 x SQL
	Toluene	450 µg/kg	6 U µg/kg	80 x SQL

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
WBG1-1 (continued)	Chlorobenzene	6 J µg/kg	6 U µg/kg	1 x SQL
	Ethylbenzene	14 J µg/kg	6 U µg/kg	2 x SQL
	Total xylenes	93 µg/kg	6 U µg/kg	20 x SQL
	1,2-Dichlorobenzene	1,200 µg/kg	380 U µg/kg	3.2 x SQL
	di-n-Butyl phthalate	3,400 µg/kg	140 J µg/kg	24 x REF
	Arsenic	28.0 mg/kg	0.2 B mg/kg	140 x REF
	Barium	2,450 mg/kg	98.0 mg/kg	25.0 x REF
	Beryllium	0.7 mg/kg	0.1 U mg/kg	7 x SDL
	Cadmium	8.0 mg/kg	0.3 U mg/kg	27 x SDL
	Calcium	23,600 mg/kg	682 mg/kg	34.6 x REF
	Chromium	113 mg/kg	5.2 mg/kg	22 x REF
	Cobalt	33 mg/kg	2.0 mg/kg	17 x REF
	Copper	3,570 mg/kg	19.0 mg/kg	188 x REF
	Iron	63,000 mg/kg	4,370 mg/kg	14 x REF
	Lead	6,730 mg/kg	5.8 mg/kg	1200 x REF
	Magnesium	4,730 mg/kg	1,160 mg/kg	4.08 x REF
	Manganese	2,210 mg/kg	174 mg/kg	12.7 x REF
	Nickel	91.0 mg/kg	3.4 mg/kg	27 x REF
	Selenium	1.3 mg/kg	0.2 U mg/kg	6.5 x SDL
	Vanadium	49.0 mg/kg	9.8 U mg/kg	5.0 x SDL
	Zinc	3,110 mg/kg	103 mg/kg	30.2 x REF
WBG2-1	1,1,1-Trichloroethane	12 µg/kg	6 U µg/kg	2 x SQL
	Trichloroethene	15 µg/kg	6 U µg/kg	3 x SQL

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
WBG2-1 (continued)	Tetrachloroethene	44 µg/kg	6 U µg/kg	7 x SQL
	1,4-Dichlorobenzene	2,700 µg/kg	380 U µg/kg	7.1 x SQL
	1,2-Dichlorobenzene	6,600 µg/kg	380 U µg/kg	17 x SQL
	1,2,4-Trichlorobenzene	1,300 µg/kg	380 U µg/kg	3.4 x SQL
	N-Nitrosodiphenylamine	4,500 µg/kg	380 U µg/kg	12 x SQL
	di-n-Butyl phthalate	1,100 µg/kg	140 J µg/kg	7.9 x REF
	bis(2-Ethylhexyl) phthalate	3,500 µg/kg	69 J µg/kg	51 x REF
	Arsenic	8.0 mg/kg	0.2 mg/kg	40 x REF
	Barium	2,450 mg/kg	98.0 mg/kg	25.0 x REF
	Beryllium	0.2 mg/kg	0.1 U mg/kg	2 x SDL
	Cadmium	3.0 mg/kg	0.3 U mg/kg	10 x SDL
	Calcium	5,990 mg/kg	682 mg/kg	8.78 x REF
	Chromium	74.0 mg/kg	5.2 mg/kg	14 x REF
	Cobalt	115 mg/kg	2.0 mg/kg	58 x REF
	Copper	661 mg/kg	19.0 mg/kg	34.8 x REF
	Iron	17,200 mg/kg	4,370 mg/kg	3.94 x REF
	Lead	13,300 mg/kg	5.8 mg/kg	2,300 x REF
	Manganese	1,190 mg/kg	174 mg/kg	6.84 x REF
	Mercury	9.9 mg/kg	0.45 mg/kg	22 x REF
	Nickel	34.0 mg/kg	3.4 mg/kg	10 x REF
	Silver	1.8 mg/kg	0.6 U mg/kg	3 x SDL
	Zinc	2,250 mg/kg	103 mg/kg	21.8 x REF

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
WBG2-3	Chloroform	17 µg/kg	6 U µg/kg	2.8 x SQL
	1,1,1-Trichloroethane	680 µg/kg	6 U µg/kg	110 x SQL
	1,2-Dichloropropane	1,500 µg/kg	6 U µg/kg	250 x SQL
	Tetrachloroethene	1,400 µg/kg	6 U µg/kg	230 x SQL
	1,1,2,2-Tetrachloroethane	35 µg/kg	6 U µg/kg	5.8 x SQL
	Toluene	17 µg/kg	6 U µg/kg	2.8 x SQL
	Chlorobenzene	73 µg/kg	6 U µg/kg	12 x SQL
	1,2-Dichlorobenzene	2,300 µg/kg	380 U µg/kg	6.1 x SQL
	1,2,4-Trichlorobenzene	1,500 µg/kg	380 U µg/kg	3.9 x SQL
	di-n-Butyl phthalate	1,400 µg/kg	140 J µg/kg	10 x REF
	Arsenic	4.8 mg/kg	0.2 mg/kg	24 x REF
	Barium	6,570 mg/kg	98.0 mg/kg	67.0 x REF
	Cadmium	1.8 mg/kg	0.3 U mg/kg	6 x SDL
	Calcium	17,400 mg/kg	682 mg/kg	25.5 x REF
	Chromium	32.0 mg/kg	5.2 mg/kg	6.2 x REF
	Cobalt	18.0 mg/kg	2.0 mg/kg	9 x REF
	Copper	212 mg/kg	19 mg/kg	11 x REF
	Iron	15,100 mg/kg	4,370 mg/kg	3.46 x REF
	Lead	1,370 mg/kg	5.8 mg/kg	240 x REF
	Manganese	984 mg/kg	174 mg/kg	5.66 x REF
	Nickel	35.0 mg/kg	3.4 mg/kg	10 x REF
	Zinc	4,710 mg/kg	103 mg/kg	45.7 x REF
KB4-3	trans-1,2-Dichloroethene	11 µg/kg	6 U µg/kg	1.8 x SQL

TABLE 5 (continued)

Sample Location No.	Compound/ Analyte	Concentration	Reference Concentration	Comments
KB4-3	Trichloroethene	86 µg/kg	6 U µg/kg	14 x SQL
(continued)	Tetrachloroethene	6.1 µg/kg	6 U µg/kg	1.0 x SQL

J = Quantitation approximate due to limitations identified during the quality control review
B = Present in blank
U = Indicates the sample was analyzed but not detected and reports the detection value
SQL = Sample Quantitation Limit
SDL = Sample Detection Limit
REF = Reference sample concentration
mg/kg = Milligrams per kilogram
µg/kg = Micrograms per kilogram

[30]

The "Olin Pine Swamp Interim Corrective Measures Report," was prepared in June 1991 by Malcolm Pirnie. Soil sampling was performed to identify the extent of excavation and treatment required for the West Burning Grounds, the Southeast Kettle, the Shotgun Proofing Area, and discrete trap sand piles. In addition, a pilot study was performed which verified the appropriateness of using vapor extraction for treatment of VOCs in the Anixter Area. Sampling of oily residue in the West Burning Grounds and the Anixter Area indicated the presence of PCBs at both locations. Excavated volumes included 592 cubic yards at the West Burning Grounds, 200 cubic yards at the Southeast Kettle, 15 cubic yards at the Shotgun Proofing Area, and 180 cubic yards from the discrete trap sand piles. The ICM recommended additional studies to identify the extent and assess the risk of the PCB contamination at the Anixter Area [27].

ABB Environmental Services (ABB) performed additional sampling at the Anixter Area for the "Site Investigation and Exposure Assessment, Olin Anixter Site," dated September 1992. Sampling performed by ABB for this report indicated maximum PCB concentrations of 105 ppm at the Anixter Area. Based on the level and depth of the PCB contamination (28 to 30 feet below ground surface), the report recommended that remediation at the Anixter Area be directed toward the VOC contamination in the subsurface soils, rather than toward the PCB contamination [1]. Under contract with Olin, VAPEX installed a soil vapor extraction system at the Anixter Area in January 1994. VAPEX provides quarterly reports quantifying removals of VOCs from the Anixter Area [50,51,52].

GROUNDWATER PATHWAY

The U.S. Geological Survey (USGS) has classified the surficial geology as ice contact stratified drift. The sediments are composed of gravel, sand, silt and clay in varying proportions and degree of sorting [39]. The depth to bedrock is 150 to 250 feet [30,31]. Bedrock in the area is New Haven Arkose, which consists of moderately fractured sandstone and conglomerate

interbedded with siltstone [6].

The Pine Swamp property is in the geographical center of the Pine Swamp Basin, and groundwater in the vicinity of Pine Swamp flows radially inward toward the onsite pond system. Flow through the ponds is north to the outlet at Treadwell Street, which leads to Lake Whitney. Due to the hilly terrain, the depth to groundwater on site varies from 0 to 35 feet [3,6,30,31]. The groundwater in the vicinity of Pine Swamp has been classified "GB/GAA" by the Water Compliance Unit of the CTDEP. Groundwater sources with a GB classification may not be suitable for public or private drinking water without treatment due to known or presumed degradation. Groundwater sources with a GAA classification are suitable for public drinking water without treatment. The goal of the state is to restore class GB/GAA waters to class GAA conditions [5].

There are no municipal groundwater wells or wellhead protection areas within 4 miles of the Pine Swamp property. The Town of Hamden is served by a mix of groundwater and surface water supplies, 80 percent of which is groundwater from the North Sleeping Giant, South Sleeping Giant, and Mt. Carmel municipal wellfields located approximately 5 miles north of the Pine Swamp property. Terminal reservoirs for the Hamden surface water supply include Lake Gaillard in North Branford, Connecticut, Lake Glen, Lake Watrous and Lake Dawson in Woodbridge, Connecticut, and the Saltonstall Reservoir on the East Haven and Branford line. Table 6 lists the populations served by the private drinking wells nearest the property [3,20].

TABLE 6

Population Served by Private Wells Near Pine Swamp

Property Owner	Business Operator	Address	Approximate Distance from Pine Swamp (feet)	Approximate Worker Population
[redacted] Farm	Gabriel [redacted]	466 Putnam Avenue	0.2 mile	5
Tech Auto	--	55 Connolly Parkway	1.3 miles	20

[8,16]

The nearest residential well is the [redacted] well, located 0.2 mile south and upgradient of the Pine Swamp property is used for drinking water for approximately five employees. The [redacted] well was sampled by NUS Corporation on May 16, 1984. Results of the sampling showed no detectable VOCs, SVOCs, or inorganic analytes, with the exception of 81 ppb zinc [31]. The Tech Auto well, located 1.3 miles northeast of the Pine Swamp property, is used for drinking

water for approximately 20 employees. The Tech Auto well was sampled by NUS Corporation on May 16, 1984. Results of the sampling showed no detectable VOCs, SVOCs, or inorganic analytes, with the exception of 14 ppb manganese [31].

Table 7 lists the estimated population within each of the specified target distance rings that receive drinking water from sources within 4 miles of Pine Swamp. Frost Associates estimated the population served by private wells by summing the total number of drilled and dug wells within each CENTRACTS block (a Cartesian data management system used by the Census Bureau) and multiplying this total by the average number of people in each household [22]. There are approximately 2.43 people per household in Hamden [11]. The nearest well is the [redacted] well, located 0.2 mile from the Pine Swamp property at 466 Putnam Avenue [3].

TABLE 7

Estimated Drinking Water Populations Served by Groundwater Sources within 4 Miles of Pine Swamp

Radial Distance From Pine Swamp (miles)	Estimated Population Served by Private Wells	Estimated Population Served by Public Wells	Total Estimated Population Served by Groundwater Sources Within the Ring
0.00 - 0.25	5	0	5
> 0.25 - 0.50	0	0	0
> 0.50 - 1.00	21	0	21
> 1.00 - 2.00	466	0	466
> 2.00 - 3.00	972	0	972
> 3.00 - 4.00	1,845	0	1,845
TOTAL	3,309	0	3,309

[15,22]

CDM personnel collected two groundwater samples (GW-01 and GW-02) from the [redacted] well on Putnam Avenue, 0.2 mile from Pine Swamp, during sampling activities on August 23, 1994.

At the sample location, groundwater was purged and pH, conductivity, and temperature were monitored until parameters stabilized. The samples were analyzed for VOCs by EPA Region I modified Method 524.2 and low concentration metals and cyanide through EPA CLP Delivery Analytical Services (DAS) for drinking water analysis. The organic and inorganic analytical results were reviewed according to Tier II data validation protocol. Table 8 identifies the samples and describes the sample locations [3,33,35].

The groundwater samples were collected from the [redacted] well due to the proximity of the private well to the Pine Swamp property; however, studies have shown that the [redacted] well is upgradient of the source areas [27,30]. Therefore, no reference sample was collected.

TABLE 8

Groundwater Sample Summary: Pine Swamp
Samples Collected by CDM on August 23, 1994

Sample Location No.	Traffic Report #	Time (hrs)	Remarks/Depth	Sample Source
GW-01	DAC076 (IS,OV)	1030	Grab	Groundwater (tap) sample collected at the [redacted] well at 466 Putnam Avene, Hamden, CT
GW-02	DAC077 (IS,OV)	1030	Grab	Duplicate of GW-01 for quality control

IS = Inorganic (DAS metals and cyanide analyses)
OV = Volatile Organics (DAS Method 524.2)

[3]

Table 9 lists all analytes detected in the groundwater samples collected by CDM. The complete analytical results of the 1994 CDM groundwater sampling activities, including quantitation and detection limits, are presented in Attachments C (DAS VOC Results) and D (DAS Inorganic Results).

Federal maximum contaminant levels (MCLs) for detected analytes are listed in Table 9. MCLs are the maximum permissible level of a contaminant in water delivered to any user of a public water system. These levels are used by EPA as standards to regulate drinking water supplies under the federal Safe Drinking Water Act [44].

TABLE 9

Summary of Analytical Results
Groundwater Sample Analysis for Pine Swamp
Collected by CDM on August 23, 1994

Sample Location No.	Compound/ Analyte	Concentration (µg/l)	MCL (µg/l)
GW-01	Chloroform	1.4	100
	Barium	38.1	2,000
	Calcium	58,700	NE
	Magnesium	8,000	NE
	Potassium	1,690	NE
	Sodium	28,400	NE
	Zinc	164	NE
GW-02	Chloroform	1.3	100
	Barium	37.7	2,000
	Calcium	58,400	NE
	Magnesium	7,960	NE
	Potassium	1,600	NE
	Sodium	29,200	NE
	Zinc	163	NE

J = Quantitation approximate due to limitations identified during the quality control review
MCL = Maximum Contaminant Level from EPA Drinking Water Regulations and Health Advisories (December 1993)
NE = No MCL has been established for this analyte
µg/l = Micrograms per liter

[33,35]

One VOC (chloroform) and several inorganic analytes, including barium, cadmium, magnesium, potassium, sodium, and zinc, were detected in the groundwater samples collected from the [redacted] well on August 23, 1994. All compounds and analytes detected in the groundwater samples were also detected in the soil samples collected for the 1988 RIS. However, the [redacted] well is believed to be located upgradient of the source areas on the Pine Swamp property [3,20,33,35].

The groundwater sample results for GW-01 and GW-02, which were collected by CDM from the [redacted] well at the same time, show good correlation. Maximum concentrations of the compounds detected in the groundwater samples are as follows: chloroform (1.4 μg/l), barium (38.1 μg/l), calcium (58,700 μg/l), magnesium (7,960 μg/l), potassium (1,690 μg/l), sodium (29,200 μg/l) and zinc (164 μg/l). All compounds listed in Table 9 were detected at concentrations less than the current MCLs. The MCL for chloroform of 100 μg/l is a MCL for total trihalomethanes (THMs) and is currently under review by EPA [33,35,44].

Malcolm Pirnie has conducted annual groundwater monitoring for Olin at the Pine Swamp property in conjunction with the RIS since April 1991. The annual groundwater report, which includes groundwater sampling from 15 onsite wells, is submitted to the CTDEP. Locations of the wells sampled are provided in Figure 3: Annual Groundwater Monitoring Locations [28].

The sampling locations represent clusters of two to three wells at various screening interval depths. The GW-03 cluster is located downgradient of the East Burning Grounds; the GW-09 cluster is located downgradient of the Anixter Area; the GW-12 cluster is located downgradient of the Southeast Kettle; the GW-14 cluster is located near the property boundary at the outlet to Lake Whitney; the GW-16 cluster is located downgradient of the West Burning Grounds; and the GW-18 cluster is located downgradient of the Battery Waste Area. Samples are analyzed for the Target Compound List using EPA method 8240, eight RCRA metals using a 0.45 μm filter, and PCBs using EPA Method 8080/608. PCBs are analyzed for samples collected from clusters GW-03, GW-09, and GW-16 only.

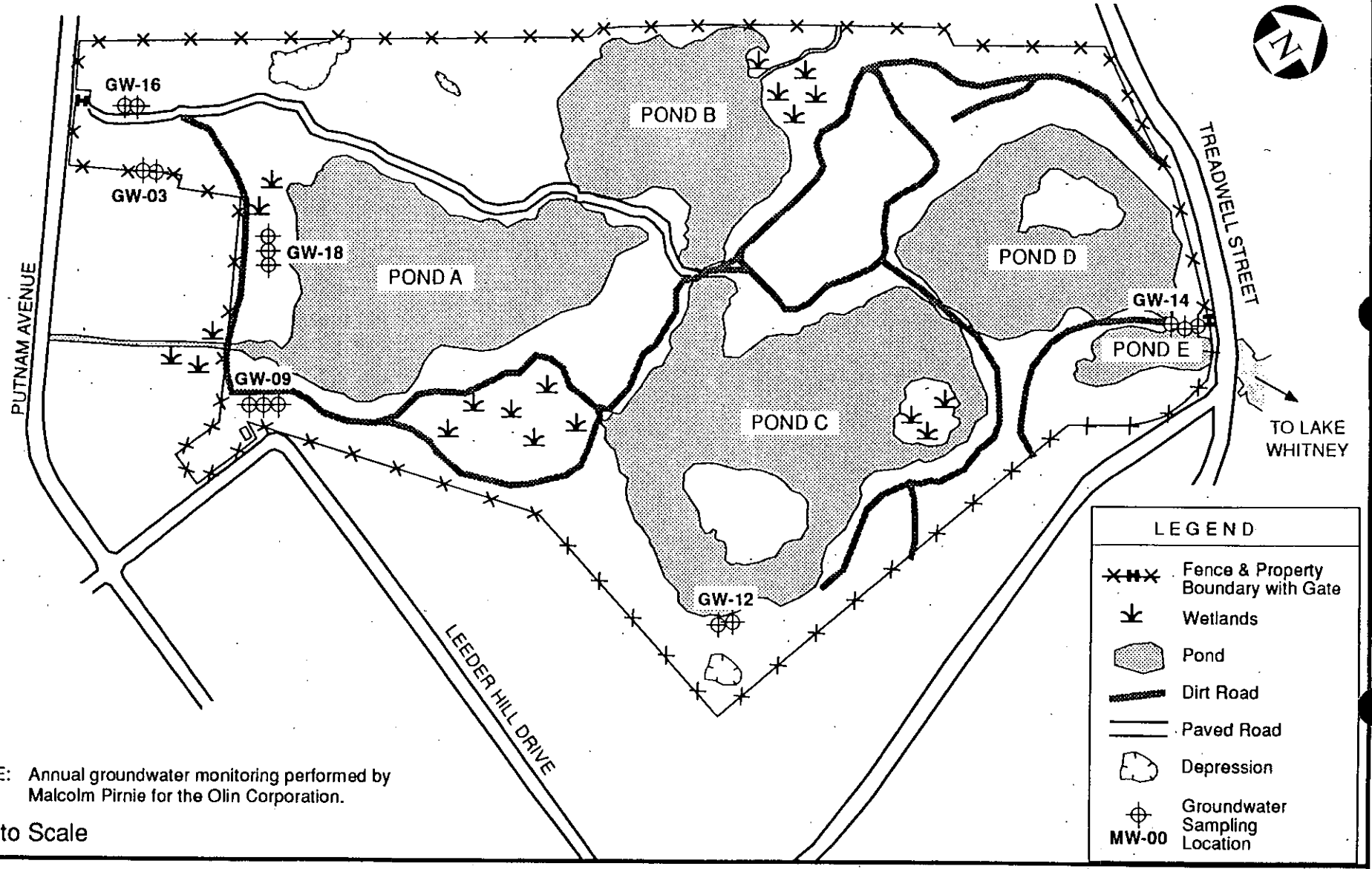
Sampling results from 1991 through 1994 show that the highest concentrations of VOCs are detected primarily in the GW-03 and GW-09 clusters. Barium and lead have been detected at low levels at all sampling locations. PCBs have been detected in the GW-03 cluster only. The maximum concentrations of contaminants for the 1993 and 1994 groundwater monitoring are provided below.

The following are maximum concentrations of compounds and analytes detected in the groundwater samples collected by Malcolm Pirnie in April 1993: 7.7 μg/l 1,1-dichloroethane detected at GW-03; 20 μg/l vinyl chloride detected in GW-03; 170 μg/l 1,2-dichloropropane detected in GW-09; 170 μg/l trichloroethene detected in GW-09; 15 μg/l benzene detected in GW-03; 1,100 μg/l tetrachloroethene detected in GW-09; 6.6 μg/l 1,1,2,2-tetrachloroethane detected in GW-03; 65 μg/l toluene detected in GW-03; 2,500 μg/l chlorobenzene detected in GW-03; 17 μg/l ethylbenzene detected in GW-03; 28 μg/l total xylenes detected in GW-03; 3.7 μg/l chloroform detected in GW-03; 15 μg/l 1,1-dichloroethene detected in GW-09; 2800 μg/l total 1,2-dichloroethene; 13 μg/l 1,2-dichloroethane detected in GW-09; 30 μg/l 1,1,1-trichloroethane detected in GW-09; 10 μg/l PCB-1248 detected in GW-03; and 0.59 μg/l barium detected in GW-09 [28].

All compounds and analytes detected in the 1993 groundwater samples, with the exception of 1,1-dichloroethene and vinyl chloride, were also detected in soil samples collected for the 1988 RIS; however, 1,1-dichloroethene and vinyl chloride are biodegradation products of trichloroethene and 1,1,2,2-tetrachloroethane, which were detected in both the RIS soil samples and the 1993 groundwater samples [28].

The following are maximum concentrations of compounds and analytes detected in the groundwater samples collected by Malcolm Pirnie in April 1994: 19 μg/l 1,1-dichloroethane detected at GW-14; 23 μg/l vinyl chloride detected in GW-03; 160 μg/l 1,2-dichloropropane detected in GW-09; 160 μg/l trichloroethene detected in GW-09; 11 μg/l benzene detected in GW-09; 550 μg/l tetrachloroethene detected in GW-09; 8.6 μg/l toluene detected in GW-16; 910 μg/l chlorobenzene detected in GW-03; 8.4 μg/l ethylbenzene detected in GW-16; 20 μg/l total xylenes detected in GW-16; 5.9 μg/l chloroform detected in GW-14; 60 μg/l 1,1-dichloroethene detected in GW-14; 2500 μg/l total 1,2-dichloroethene; 9.7 μg/l 1,2-dichloroethane detected in GW-09; 82 μg/l 1,1,1-trichloroethane detected in GW-14; 2 μg/l PCB-1248 detected in GW-03; and 0.56 μg/l barium detected in GW-09. Three compounds were detected in the 1994 groundwater sampling which were not detected in the 1993 groundwater sampling, including methylene chloride (maximum concentration 3.4 μg/l); carbon disulfide (maximum concentration 72 μg/l); 1,1,2-trichloroethene (maximum concentration 2.9 μg/l); and carbon tetrachloride (maximum concentration 2.4 μg/l) [29].

All compounds and analytes detected in the 1994 groundwater samples, with the exception of 1,1-dichloroethene, vinyl chloride, 1,1,2-trichloroethane and carbon disulfide, were also detected soil samples collected for the 1988 RIS; however, 1,1-dichloroethene, vinyl chloride and 1,1,2-trichloroethane are biodegradation products of trichloroethene and 1,1,2,2-tetrachloroethane, which were detected in both the RIS soil samples and the 1993 groundwater samples [29].



NOTE: Annual groundwater monitoring performed by Malcolm Pirnie for the Olin Corporation.

Not to Scale

ANNUAL GROUNDWATER MONITORING LOCATIONS
PINE SWAMP
HAMDEN, CONNECTICUT

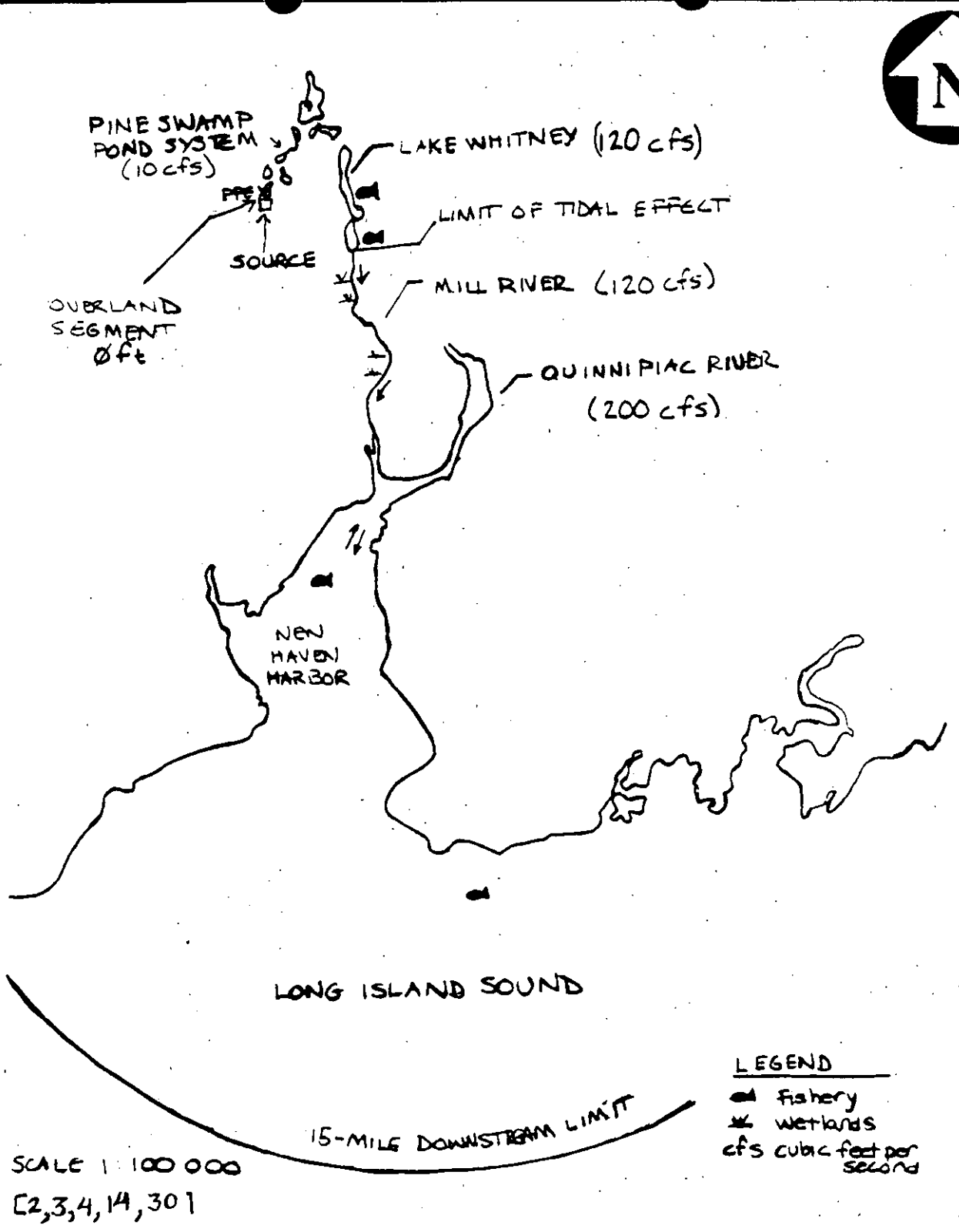
CDM FEDERAL PROGRAMS CORPORATION
a subsidiary of Camp Dresser & McKee Inc.

Figure 3

SURFACE WATER PATHWAY

Runoff from the Pine Swamp property flows radially inward to the onsite ponds. Ponds A and B also receive urban runoff discharge from a stream at Putnam Avenue and a storm sewer at the east end of Oregon Avenue, respectively. The most upstream probable point of entry for surface water from the Pine Swamp source areas is 0 feet to the Pine Swamp pond system [3]. Source areas adjacent to the onsite ponds may be located inside the 100-year flood plain [40]. The onsite ponds are classified as B/AA by the State of Connecticut and are protected for the maintenance of aquatic life under the Clean Water Act [21].

The onsite ponds flow north from Pond A to Pond E through a culvert under Treadwell Street into Lake Whitney, a former drinking water supply formed by a dam on the Mill River. The drinking water intake is approximately 3 miles downstream from the probable point of entry at Pine Swamp. Use of Lake Whitney for drinking water was discontinued in August 1991 due to a decrease in demand. Because the SCCRWA has no plans to use Lake Whitney in the near future and the SCCRWA would require approximately 6 months to upgrade the current treatment facility at Lake Whitney before bringing the facility back online, the intake does not qualify as a standby intake [12,17]. Lake Whitney flows into the Mill River, which flows into New Haven Harbor and Long Island Sound (see Figure 4: Surface Water Pathway and Table 10: Water Bodies Within the Surface Water Segment of Pine Swamp) [47].



SURFACE WATER PATHWAY
PINE SWAMP
HAMDEN, CONNECTICUT

CDM FEDERAL PROGRAMS CORPORATION
a subsidiary of Camp Dresser & McKee Inc.

Figure 4

TABLE 10

Water Bodies Within the Surface Water Segment of Pine Swamp

Surface Water Body	Descriptor[a]	Length of Reach	Flow Characteristics (cfs)[b]	Length of Wetlands
Pine Swamp Pond System	Small to moderate stream	1.5 miles	Unknown	None
Lake Whitney	Moderate to large stream	0.9 mile	120	None
Mill River	Moderate to large stream	3.4 miles	120	3,150 feet
New Haven Harbor	Coastal tidal waters	3.2 miles	Tidal	None
Long Island Sound	Shallow ocean zone	6 miles	Ocean	None

[a] Minimal stream. Small to moderate stream. Moderate to large stream. Large stream to river. Very large river. Coastal tidal waters. Shallow ocean zone or Great Lake. Deep ocean zone or Great Lake. Three-mile mixing zone in quiet flowing river.

[b] Cubic feet per second.

[3,14,48]

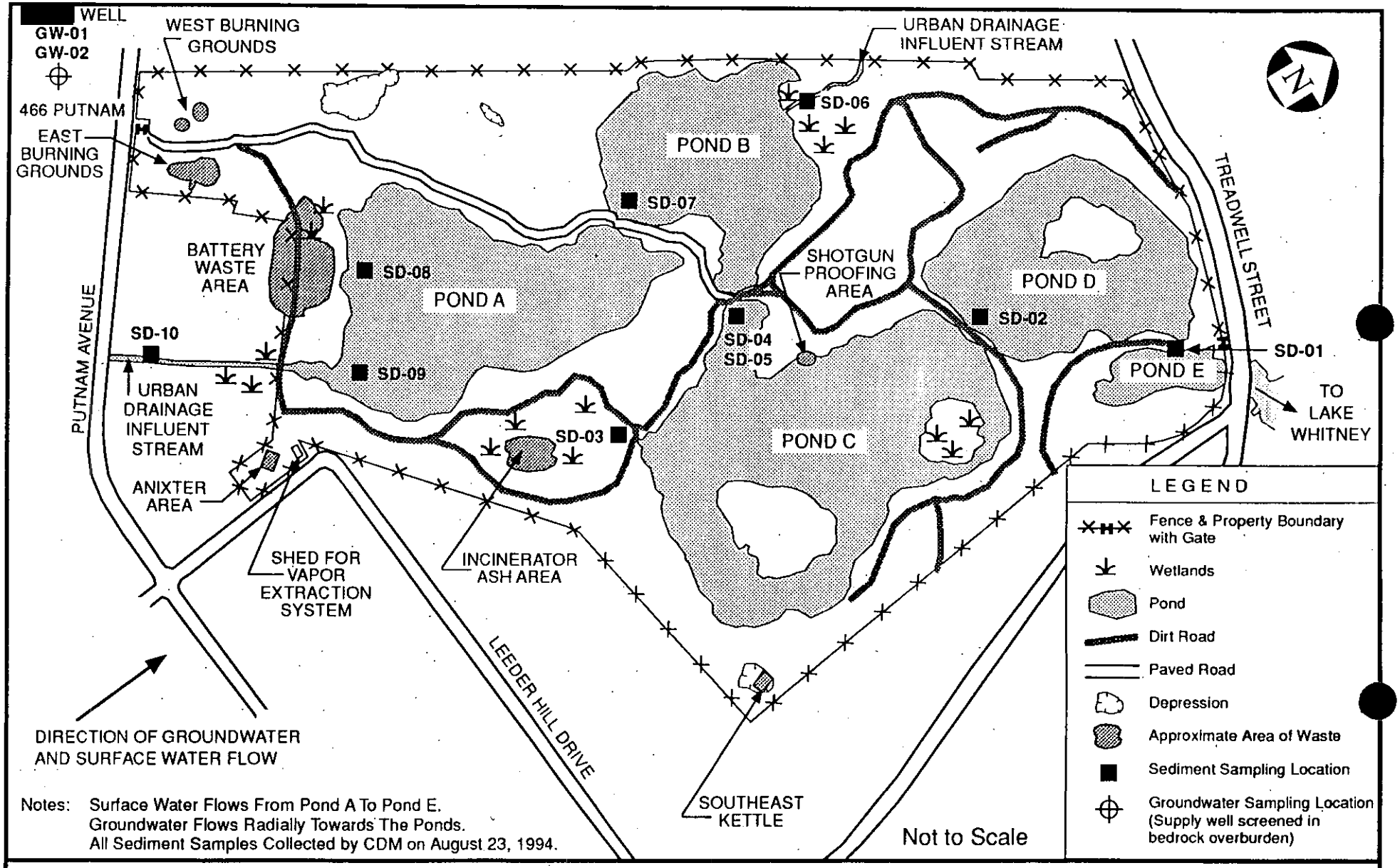
The SCCRWA performs routine monitoring for VOCs at the point where the Pine Swamp pond system flows into Lake Whitney. VOCs were detected in one of the four samples collected during the period of May 1993 to June 1994, including 1,1,1-trichloroethane (0.7 μg/l), cis-1,2-dichloroethene (0.7 μg/l), tetrachloroethene (1.1 μg/l), and trichloroethene (0.9 μg/l). No VOCs were detected in the remaining three samples. The SCCRWA also collects samples at the Lake Whitney intake structure. VOCS were detected in one of the four samples collected during the period of May 1993 through June 1994, including cis-1,2-dichloroethene (0.6 μg/l) and trichloroethene (0.6 μg/l). No VOCs were detected in the remaining three samples [19].

Onsite pond fish species include blue gill sunfish and pumpkinseed sunfish [30]. Lake Whitney fish species include largemouth bass, blue gill sunfish, pumpkin seed sunfish, yellow perch, carp, white suckers, brown bullhead, golden shriner, and black crappy. Mill River fish species include black crappy, white sucker, brown bullhead, American eel, mummychug and silverside [9].

Sixty-seven finfish and squid species were identified by CTDEP as species that may be found in New Haven Harbor [4]. Eighty species of finfish and 22 species of invertebrates were caught and identified in Long Island Sound from 1984 to 1992 [4].

Sensitive environments within 15 miles downstream of the Pine Swamp property include wetlands on the Mill River and New Haven Harbor, which is designated as a critical spawning area for the maintenance of winter flounder (*Pleuronectes americanus*) [4,47].

On August 23, 1994, CDM personnel collected 10 sediment samples from the onsite ponds and urban drainage inlet streams (SD-01 through SD-10). A CLP laboratory performed the analysis for the sediment samples, including the full Target Compound List/Target Analyte List (TCL/TAL) using the CLP Routine Analytical Services (RAS). One trip blank and one equipment blank were also collected and submitted for analysis along with the sediment samples, and PE samples. The organic and inorganic analytical results were reviewed according to Tier II data validation protocol. The organic and inorganic analytical results were reviewed according to Tier II data validation protocol [33,34,35,36]. Figure 5: Site Sketch with Sampling Locations and Table 11 identify the samples and describes the sample locations.



Notes: Surface Water Flows From Pond A To Pond E.
Groundwater Flows Radially Towards The Ponds.
All Sediment Samples Collected by CDM on August 23, 1994.

SITE SKETCH WITH SEDIMENT SAMPLING LOCATIONS
PINE SWAMP
HAMDEN, CONNECTICUT

CDM FEDERAL PROGRAMS CORPORATION
a subsidiary of Camp Dresser & McKee Inc.

Figure 5

TABLE 11

Sediment Sample Summary: Pine Swamp
Samples Collected by CDM on August 23, 1994

Sample Location No.	Traffic Report #	Time (hrs)	Remarks/Depth	Sample Source
TB-01	AHS35 (O-VOA)	0915	Grab	Trip Blank for RAS QC
SD-01	AHS21 (O) MAGG21 (I)	1030	Grab	Sample collected from the culvert outlet to Pond E from Pond D
SD-02	AHS22 (O) MAGG22 (I)	1100	Grab	Sample collected from the culvert outlet to Pond D from Pond C
SD-03	AHS23 (O) MAGG23 (I)	1300	Grab	Sample collected from the culvert outlet to Pond C from the wetlands adjacent to the Incinerator Ash Area
SD-04	AHS24 (O) MAGG24 (I)	1245	Grab	Sample collected from the culvert outlet to Pond C from Pond B
SD-05	AHS25 (O) MAGG25 (I)	1245	Grab	Duplicate of SD-04 for QC
SD-06	AHS26 (O) MAGG26 (I)	1330	Grab	Sample collected from the urban drainage influent stream to Pond B below the property boundary; reference sample
SD-07	AHS27 (O) MAGG27 (I)	1330	Grab	Sample collected from the culvert outlet to Pond B from Pond A
SD-08	AHS28 (O) MAGG28 (I)	1505	Grab	Sample collected from Pond A adjacent to the Battery Waste Area
SD-09	AHS29 (O) MAGG29 (I)	1500	Grab	Sample collected from where the urban drainage inlet stream meets Pond A
SD-10	AHS30 (O) MAGG30 (I)	1600	Grab	Sample collected from the urban drainage inlet stream to Pond A; reference sample

I = Inorganic (RAS metals and cyanide analyses)
O = Organic (RAS volatile organic, semivolatile organic, and P/PCB analyses)
VOA = Volatile Organics
P/PCB = Pesticides/Polychlorinated biphenyl
RAS = Routine Analytical Services
QC = Quality Control

[3]

Table 12 summarizes analytical results of the sediment samples collected. Although two reference samples were collected (sediment samples SD-06 and SD-10) sediment sample SD-10 was used for comparison with other results because SD-10 represents offsite contamination entering Pond A, which is the first pond in the Pine Swamp pond system. In addition, concentrations were higher in SD-10 than in SD-06 [3,34,36].

For each sample location, a compound or analyte is listed if it is detected at a concentration three times or greater than the reference sample concentration. Compounds or analytes that occur at a concentration three times or greater than the reference concentration are designated by their approximate relative concentration above the reference value. If the compound or analyte was not detected in the reference sample, the SQL or SDL is used as a reference value. Accordingly, compounds/analytes are listed by their approximate concentration above the SQL/SDL only if they occur at a concentration equal to or greater than the reference sample's SQL/SDL [24,34].

TABLE 12

Summary of Analytical Results Sediment Sample Analysis for Pine Swamp

Sample Location No.	Compound/Analyte	Concentration	Reference Concentration	Comments
SD-02	Beryllium	0.39 J mg/kg	0.8 J µg/kg	4.9 x REF
SD-03	Di-n-butyl phthalate	570 µg/kg	400 U µg/kg	1.4 x SQL
	4,4'-DDE	13 µg/kg	4.1 U µg/kg	3.2 x SQL
	4,4'-DDT	5.8 J µg/kg	4.0 U µg/kg	1.4 x SQL
	Aluminum	18,500 mg/kg	3,970 mg/kg	4.66 x REF
	Calcium	10,100 mg/kg	1,590 mg/kg	6.35 x REF
	Cobalt	10.7 mg/kg	2.7 mg/kg	4.0 x REF
	Copper	98.2 mg/kg	25.5 mg/kg	3.85 x REF
	Lead	314 J mg/kg	67.9 J mg/kg	4.62 x REF
	Magnesium	4,470 mg/kg	1,380 mg/kg	3.24 x REF

TABLE 12 (continued)

Sample Location No.	Compound/Analyte	Concentration	Reference Concentration	Comments
SD-03 (continued)	Manganese	327 mg/kg	73.2 mg/kg	4.47 x REF
	Vanadium	65.4 mg/kg	18.9 mg/kg	3.46 x REF
SD-04	Magnesium	4,450 mg/kg	1,380 mg/kg	3.22 x REF
SD-07	Mercury	0.19 mg/kg	0.05 U mg/kg	3.8 x SDL
SD-08	Acetone	450 J µg/kg	12 UJ µg/kg	38 x SQL
	Acenaphthylene	2,200 J µg/kg	36 J µg/kg	61 x REF
	Fluorene	910 J µg/kg	270 J µg/kg	3.4 x REF
	Anthracene	930 J µg/kg	310 J µg/kg	3.0 x REF
	Pyrene	18,000 J µg/kg	3,000 J µg/kg	6.0 x REF
	Fluoranthene	42,000 J µg/kg	5,900 µg/kg	7.1 x REF
	Benzo(a)anthracene	15,000 J µg/kg	2,100 J µg/kg	7.1 x REF
	Chrysene	19,000 J µg/kg	1,400 J µg/kg	14 x REF
	Benzo(b)fluoranthene	44,000 J µg/kg	2,600 µg/kg	17 x REF
	Benzo(k)fluoranthene	11,000 J µg/kg	820 µg/kg	13 x REF
	Benzo(a)pyrene	18,000 J µg/kg	1,400 µg/kg	13 x REF
	Indeno(1,2,3-cd)pyrene	7,200 J µg/kg	500 µg/kg	14 x REF
	Dibenz(a,h)anthracene	1,500 J µg/kg	76 J µg/kg	20 x REF
	Benzo(g,h,i)perylene	5,700 J µg/kg	370 J µg/kg	15 x REF
	Aluminum	37,700 J mg/kg	3,970 mg/kg	9.50 x REF
	Arsenic	19.1 J mg/kg	0.65 U mg/kg	29 x SDL
	Barium	276 J mg/kg	41.2 U mg/kg	6.70 x SDL
	Beryllium	1.2 J mg/kg	0.08 J mg/kg	15 x REF

TABLE 12 (continued)

Sample Location No.	Compound/Analyte	Concentration	Reference Concentration	Comments
SD-08 (continued)	Cadmium	10.6 J mg/kg	0.84 UJ mg/kg	13 x SDL
	Calcium	6,520 J mg/kg	1,510 mg/kg	4.32 x REF
	Chromium	128 J mg/kg	14.2 J mg/kg	9.01 x REF
	Cobalt	18.4 J mg/kg	2.7 mg/kg	6.8 x REF
	Copper	396 J mg/kg	25.5 mg/kg	15.5 x REF
	Iron	35,500 J mg/kg	8,940 mg/kg	3.97 x REF
	Lead	817 J mg/kg	67.9 J mg/kg	12.0 x REF
	Magnesium	7,120 J mg/kg	1,380 mg/kg	5.16 x REF
	Manganese	751 J mg/kg	73.2 mg/kg	10.3 x REF
	Mercury	1.4 J mg/kg	0.05 U mg/kg	28 x SDL
	Nickel	57.9 J mg/kg	8.1 U mg/kg	7.2 x SDL
	Potassium	3,460 J mg/kg	368 UJ mg/kg	9.40 x SDL
	Selenium	3.3 J mg/kg	0.18 U mg/kg	18 x SDL
	Silver	2.5 J mg/kg	0.76 U mg/kg	3.3 x SDL
	Sodium	800 J mg/kg	234 U mg/kg	3.4 x SDL
	Vanadium	92.1 J mg/kg	18.9 mg/kg	34.9 x REF
	Zinc	3,490 J mg/kg	74.4 mg/kg	46.9 x REF
SD-09	Chlorobenzene	48 µg/kg	12 U µg/kg	4.0 x SQL
	4,4'-DDT	73 µg/kg	4 U µg/kg	18 x SQL
	Copper	77.4 mg/kg	25.5 mg/kg	3.04 x REF

REF = Reference concentration.
SDL = Sample detection limit.
J = Quantitation is estimated due to limitations identified in quality control review.
U = The analyte was analyzed for, but the value reported is the sample limit.
UJ = The analyte was analyzed for, but was not detected. The sample detection limit is an estimated quantity.
µg/kg = Micrograms per kilogram

mg/kg = Milligrams per kilogram

[34,36]

Results of the CDM 1994 SIP sediment sampling have indicated the presence of VOCs, SVOCs, pesticides, and inorganic analytes at greater than three times the reference concentration, sample quantitation limit, or sample detection limit. Five of the sediment samples, SD-01, SD-02, SD-04, SD-05, and SD-07, were collected from the downstream side of the culverts between the ponds. Fishing line was found in the water and sediments at these sample locations [3,34,36].

The highest concentration of the compounds and analytes were detected in sample SD-08, which was collected immediately downgradient of the Battery Waste Area at the edge of Pond A. Based on the 1988 RIS source area delineation, sample SD-08 could be within the Battery Waste Area. Therefore, SD-08 characterizes contamination in the sediment at the Battery Waste Area, but may not document migration of contamination to a target fishery location [34,36].

SOIL EXPOSURE PATHWAY

Soil sampling events at the Pine Swamp property are summarized in the Waste/Source Sampling section of this report. Sample IA-6 was collected by Malcolm Pirnie between 6 and 12 inches below the ground surface in the Incinerator Ash Area. Results for Sample IA-6 indicated the presence of seven VOCs, seven SVOCs, and 19 inorganic analytes [27]. No soil has been excavated from the Incinerator Ash Area since the soil sampling was performed in February 1988 [3].

Soil samples IA-1, IA-2, I-A4, and WBG2-1, collected by Malcolm Pirnie, also may have been collected within the first 2 feet of the ground surface. The depth range of these samples is from 0 feet to 5 feet. The results of these samples also indicated the presence of VOCs, SVOCs, and inorganic analytes. In addition, PCBs were detected in samples IA-1 and IA-2 at greater than three times the background concentration (or sample quantitation limit). Soil sample WBG2-1 was collected from the West Burning Grounds in January 1988 before 592 cubic yards of soil was excavated from the source area in 1990 [30].

There are no residents, schools, or day-care facilities onsite or within 200 feet of the property. There are no recreational facilities on the property. No persons work onsite [3]. Approximately 15,319 persons live within 1 mile of the property [22]. Access to the property is restricted by a maintained chain link fence [3]. No terrestrial sensitive environments exist in the area of observed contamination [26].

AIR PATHWAY

No air sampling was conducted at the Pine Swamp property. In addition, no air sampling was performed during previous site activities. During CDM site reconnaissance and sampling activities, monitoring equipment detected no organic vapors [3].

There are no onsite residents. The nearest resident is on Leeder Hill Drive abutting Pine Swamp's eastern property boundary. There are an estimated 178,899 persons living within 4 miles of Pine Swamp [17]. Table 13 summarizes the estimated population within 4 miles of Pine Swamp.

TABLE 13

Estimated Population within 4 Miles of Pine Swamp

Radial Distance From Pine Swamp (miles)	Estimated Population
0.00 - 0.25	399
> 0.25 - 0.50	3,119
> 0.50 - 1.00	11,801
> 1.00 - 2.00	40,972
> 2.00 - 3.00	68,297
> 3.00 - 4.00	54,311
TOTAL	178,899

[20]

Sensitive environments within 4 miles of the Pine Swamp property include 11 federally endangered species, 3 federally threatened species, and approximately 29 acres of wetlands [26,45,46,47,48].

SUMMARY

Pine Swamp is located at 475 Putnam Avenue, in Hamden, New Haven County, Connecticut. This 103.6-acre property is owned by Olin Corporation (Olin) of Stamford, Connecticut. For more than 60 years, Winchester Repeating Arms Company, owned by Olin, stored gunpowder on the property. Shotgun, small caliber rifle, machine gun, and artillery shells, as well as mortar rounds were tested at firing ranges on the Pine Swamp property. Olin also used the Pine Swamp property for the disposal and incineration of materials generated at the New Haven Winchester plant, including "wood, demolition debris, miscellaneous metals and glass, trash, waste gunpowder and solvent chemicals, off-specification dry cell batteries, concrete test pads, trap sands from firing ranges, and incinerator ash." The waste was disposed of on the property from the late 1950s and continued until the late 1960s.

In 1966, a private citizen complaint to the Hamden Health Department initiated the cessation of disposal and the commencement of restoration of the Pine Swamp property. Olin Corporation entered into a Consent Order with the Connecticut Department of Environmental Protection (CTDEP) in January 1986 to identify and remediate contaminated areas on the property.

A December 1988 Remedial Investigation Study (RIS) identified the following disposal areas which are included as source areas: the East Burning Grounds, the West Burning Grounds, the Battery Waste Area, the Anixter Area, the Southeast Kettle Area, the Incinerator Ash Area, the Shotgun Proofing Area and the Trap Sands. Sampling performed for the RIS indicated the presence of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and inorganic analytes in the source areas.

The depth to groundwater onsite varies from 0 to 35 feet. The nearest community water supply is located at the North Sleeping Giant, South Sleeping Giant, and Mt. Carmel wells, approximately 5 miles north of the property. The total number of people served by groundwater sources within 4 miles of the property is 3,309.

CDM conducted sediment sampling at the property and groundwater sampling at the nearest drinking water well on August 23, 1994. Results of CDM 1994 SIP groundwater sampling at the [redacted] well, 0.2 mile upgradient of Pine Swamp, indicated the presence of chloroform (1.4 µg/l), barium (38.1 µg/l), calcium (58,700 µg/l), potassium (1,690 µg/l), sodium (29,200 µg/l) and zinc (164 µg/l). All compounds and analytes detected in the groundwater samples were also detected in the soil samples collected for the 1988 RIS. None of the reported concentrations exceeded federal Maximum Contaminant Levels (MCLs).

Overland runoff flows from various points on the property to the onsite ponds. The probable point of entry (PPE) of contaminants from an onsite source area is 0 feet. The Pine Swamp pond system is hydrologically connected to Lake Whitney, a former public drinking water supply formed by a dam on the Mill River. The Mill River flows into New Haven Harbor and Long Island Sound. No active drinking water intakes exist along the 15-mile surface water pathway associated with the property. The Lake Whitney intake is located 3 miles downstream of the

Pine Swamp pond system, but is not in use and does not qualify as a standby intake. Fisheries exist in all segments of the surface water path.

Sensitive environments within 15 miles downstream of the Pine Swamp property include wetlands on the Mill River and the New Haven Harbor, which is designated as a critical spawning area for the maintenance of winter flounder (*Pleuronectes americanus*) [19,43].

On August 23, 1994, CDM personnel collected 10 sediment samples from the onsite ponds and urban drainage inlet streams. Results of the CDM 1994 SIP sediment sampling indicated the presence of VOCs, SVOCs, pesticides, and inorganic analytes at greater than three times the reference concentration. The highest concentration of the compounds and analytes were detected in sample SD-08, which was collected adjacent to the Battery Waste Area at the edge of Pond A.

There are no residents, schools, or day-care facilities onsite or within 200 feet of the property. There are no recreational facilities on the property. No persons work onsite. Approximately 15,319 persons live within 1 mile of the property. Access to the property is restricted by a maintained chainlink fence. No terrestrial sensitive environments exist in the area of observed contamination.
Results of soil sampling at the Pine Swamp property for the RIS indicated the presence of VOCs, SVOCs, and inorganic analytes within 2 feet of the ground surface. Several source areas, including the West Burning Grounds, the Southeast Kettle, the Shotgun Proofing Area and Trap Sands, have been excavated after sampling was performed for the RIS.

The nearest resident is located on Leeder Hill Drive abutting Pine Swamp's eastern property boundary. An estimated 178,899 persons live within 4 miles of Pine Swamp. Sensitive environments within 4 miles of the Pine Swamp property include 11 federally endangered species, 3 federally threatened species, and approximately 29 acres of wetlands. No air sampling was conducted at the Pine Swamp property. In addition, no air sampling was performed during previous site activities. During CDM site reconnaissance and sampling activities, monitoring equipment detected no organic vapors.

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ATTACHMENT A

Pine Swamp Organic Analytical Results and Sample Quantitation Limits
CDM Federal Programs Corporation (August 23, 1994)

ATTACHMENT B

Pine Swamp Inorganic Analytical Results and Sample Detection Limits
CDM Federal Programs Corporation (August 23, 1994)

ATTACHMENT C

Pine Swamp Delivery Analytical Services Volatile Organic Compound Results and Sample Quantitation Limits CDM Federal Programs Corporation (August 23, 1994)

ATTACHMENT D

Pine Swamp Delivery Analytical Services Inorganic Results and Sample Detection Limits CDM Federal Programs Corporation (August 23, 1994)